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Innovative System Design and Development I Project Report

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Dyslexia Diagnosis and Educational Game System

Pınar Cindemir
201911018
Beyza Çay
201911020
Mustafa Mert Aydın
201911011
Göktuğ Erdem
201911034
Kutay Kaymakçı
201911034

Advisor: Dr. Murat Saran

CONTENTS

Literature Review

Abstract

[EN] This study examines the effects, diagnosis, and treatment of dyslexia, a neurological disorder, on children. It aims to determine how to create the most beneficial educational content for children by comparing the software tools used. The study examines dyslexia in two different areas: health and software. The health side of the study is designed to observe children with this disorder better and discuss the disease's effects on children. The software side of the study examines the software used in diagnosing and treating this disorder and the projects that have been done so far. Our study will help you to understand better what dyslexia means for children, to evaluate the tasks done in this regard, and to learn about the diversity of software.

[TR] Bu çalışma, nörolojik bir bozukluk olan disleksinin çocuklar üzerindeki etkilerini, teşhisini ve tedavisini incelemektedir. Kullanılan yazılım araçlarını karşılaştırarak çocuklar için en faydalı eğitim içeriğinin nasıl oluşturulacağını belirlemeyi amaçlar. Çalışma disleksiyi iki farklı alanda incelemektedir: sağlık ve yazılım. Çalışmanın sağlık tarafı, bu bozukluğu olan çocukları daha iyi gözlemlemek ve hastalığın çocuklar üzerindeki etkilerini tartışmak için tasarlanmıştır. Çalışmanın yazılım tarafı, bu bozukluğun teşhis ve tedavisinde kullanılan yazılımları ve bugüne kadar yapılmış projeleri incelemektedir. Çalışmamız, disleksinin çocuklar için ne anlama geldiğini daha iyi anlamanıza, bu konuda yapılan görevleri değerlendirmenize ve yazılım çeşitliliği hakkında bilgi edinmenize yardımcı olacaktır.

1. Introduction

Dyslexia is characterized by an unexpected difficulty in reading in children and adults who otherwise possess the intelligence, motivation, and schooling considered necessary for accurate and fluent reading. Dyslexia (or specific reading disability) is the most common and most carefully studied of the learning disabilities, affecting 80 percent of all those identified as learning disabled [1]. Although the diagnosis and implications of dyslexia were once quite uncertain, recent advances in our knowledge of its epidemiology, neurobiology, and genetics, as well as of the cognitive influences on this disorder, now allow physicians to approach dyslexia within the framework of a traditional medical model. Dyslexia, which has six types (Phonological Dyslexia, Surface Dyslexia, Visual dyslexia, Primary Dyslexia, Secondary (Developmental) Dyslexia, and Trauma Dyslexia), begins to be seen chiefly in childhood.

Dyslexia is caused by impairment in the language processing center in the brain's left hemisphere. Theories put forward to suggest that an individual with dyslexia has a genetic predisposition; that is, if family members also have dyslexia, the suspicion of dyslexia increases. The standard method used in diagnostic studies of dyslexia is Electroencephalogram (EEG). There are many treatment methods for dyslexia, and a few of them are vocabulary development, word prediction, text-to-speech, and pronunciation recording. These can be treated face-to-face or with applications on smart devices.

Many applications have been developed to identify or treat dyslexia. The algorithms used in these applications are classification algorithms and kNN algorithm-like algorithms. The common language used for such algorithms is the Python programming language. Python is a programming language because it has built-in machine learning algorithms and is also open source. These applications are educational games developed to support individuals' learning processes and are designed to motivate them and attract their attention. Such applications are made considering the participation of various stakeholders such as teachers, students, psychologists, software engineers, and more. When we look at the various mobile applications designed to diagnose children with learning disabilities in the mobile

application world, the most downloaded and voted on are the Dyslexia Quiz, Reversals For Dyslexia, and Smartex. Innovative Exercises are Dyslexia AI, Auto Train Brain, Read&Write Gold, Speechify, Dyslexia Quest, Writing Wizard, and Simplex Spelling Light.

2. Dyslexia from a health perspective

2.1. What is Dyslexia?

Dyslexia is a neurodevelopmental condition characterized by slow and imprecise word identification. Dyslexia has been a feature of every culture study, and growing evidence suggests that its neurobiological and neurocognitive underpinnings resemble each other across languages [2].

2.2. What Causes Dyslexia?

The reasons for dyslexia are not fully understood. It may be linked to genetic factors or other factors that may affect brain development. It may be related to an impairment in the brain's ability to process phonemes. It is not caused by an intellectual disability and is neurobiological in origin. It is not caused by an intellectual disability and is neurobiological in origin. Olson did not find any obvious cultural or obvious biological (ie brain-damaged) causes of dyslexic problems other than the usual genetic and environmental conditions [3].

As with all behavioral disorders, the cause of dyslexia is multifactorial and associated with multiple genes and environmental risk factors. Dyslexia is a familial disorder with moderate heritability, and replicated linkage studies have linked nine risk loci (DYX1-DYX9), although not all studies have replicated these findings. The major advance in dyslexia genetics since the last Lancet seminar was the identification of six candidate genes [4].

2.3. Which Types of Dyslexia Have?

There are six different types of dyslexia. These;

1. Phonological dyslexia: People may have difficulty pronouncing some words in this type of dyslexia. Visual processing problems are more prominent than auditory problems in this type of dyslexia..
2. Surface dyslexia: This is the type of dyslexia that causes difficulty in recognizing and writing out words.
3. Visual dyslexia: Difficulties in reading caused by problems with vision (due to physical causes) or problems with visual processing (due to cognitive/neurological causes).
4. Primary dyslexia: This is the most common form of dyslexia. It is a functional disorder that occurs in the left hemisphere of the brain and does not change with age.
5. Secondary (developmental) dyslexia: Secondary dyslexia is the result of problems in brain development during the early stages of fetal development. As a child grows, developmental dyslexia may improve.
6. Trauma dyslexia: This occurs in adults or children. It occurs when the brain is damaged by trauma or disease.

2.4. Age Groups Affected by Dyslexia

Dyslexia is most commonly diagnosed in childhood. A significant minority of the child population is affected by this disease. Prevalence rates vary according to the criteria used to define the disease, the measures used to assess reading ability and environmental factors. The prevalence rates of dyslexia vary between 3 % and 15 % of children of school age. Several epidemiological studies have reported that dyslexia is slightly more common in males than females. However, a meta-review of all these studies showed that dyslexia is diagnosed more often in males than in females, and in studies of the samples cited, the ratio of males to females was up to six times higher. A higher incidence of comorbid conduct diseases, such as attention deficit hyperactivity disorder (ADHD), has often been attributed to the over-representation of males in referred samples, in males with dyslexia than in females with dyslexia. Fewer studies have investigated the prevalence of poor comprehension. However, in

unselected samples, recent studies suggest that between 7.5% and 10% of primary school children are affected by this reading disability. Unlike dyslexia, poor reading comprehension appears to affect similar numbers of males and females. Of course, dyslexia and reading disability are best thought of as extremes of the normal distribution of reading ability. They are not distinct categories, so prevalence rates are a function of the arbitrary cut-off points used to define the disorder [5].

2.5. Effects of Dyslexia?

Dyslexia does not have significant effects, but it does have minor effects. Even if someone with dyslexia recognizes speech sounds, they may have difficulty learning their relationships to letters or words. Often seen as a reading disorder, dyslexia can also affect attention and memory, and the areas of the brain that process language.

People with dyslexia have average intelligence and usually have no problems with their vision. Most dyslexic children can do well in school with tutoring or special education programs. Emotional support plays an important role in coping with dyslexia.

Although there is no specific treatment for dyslexia, early diagnosis and intervention give the best results. However, in some cases, dyslexia may go undiagnosed for years and not be recognized until adulthood. However, it is never too late to get help and support for dyslexia.

2.6. Essential Metrics of Dyslexia

The above are the essential metrics of dyslexia

1. **Hearing and Speech Metrics**

   Phonological awareness: This is the ability to recognize and manipulate the sounds in words.

   Rapid naming: This is the ability to quickly name objects or symbols. People with dyslexia may be slower than average at rapid naming tasks.

   Articulation: This is the ability to produce speech sounds correctly. People with dyslexia may have difficulty with articulation, which can lead to speech errors such as lisping or dropping sounds.

2. **Vision, Reading, and Spelling metrics**

   Word recognition accuracy: The ability to accurately identify and pronounce words. People with dyslexia may have difficulty with word recognition, which can slow reading and poor reading comprehension.

   Reading fluency: This is the ability to read smoothly and effortlessly. People with dyslexia may have difficulty with reading fluency, which can make it difficult to read aloud or to read for extended periods.

3. **Writing and speed ability metrics**

   Writing speed: This is the rate at which a person can write legibly. People with dyslexia may have difficulty with writing speed, which can make it difficult to complete writing tasks on time.

4. **Arithmetic and time-managing metrics**

   Number sense: This is the ability to understand and manipulate numbers. People with dyslexia may have difficulty with number sense, which can lead to problems with arithmetic and mathematics.

   Time management: This is the ability to plan and organize one's time effectively. People with dyslexia may have difficulty with time management, which can make it difficult to complete tasks on time.

5. **Memory and cognition metrics**

   Short-term memory: This is the ability to hold information in one's mind for a short time. People with dyslexia may have difficulty with short-term memory, which can make it difficult to remember instructions or to follow a multi-step process.

   Working memory: This is the ability to hold information in one's mind while simultaneously performing other tasks. People with dyslexia may have difficulty with working memory, which can make it difficult to follow directions or to learn new information.

   Processing speed: This is the speed at which a person can process information. People with dyslexia may have a slower processing speed than average, which can make it difficult to keep up with classroom instruction or to complete tasks quickly.

6. **Behavior, health, development,and personality Metrics**

   Self-esteem: People with dyslexia may have low self-esteem due to their struggles with reading and writing.

   Anxiety: People with dyslexia may experience anxiety related to schoolwork or social situations.

   Motivation: People with dyslexia may have difficulty staying motivated in school due to their learning challenges.

   Social skills: People with dyslexia may have difficulty with social skills due to their struggles with reading and communication.

7. **General characteristic metrics**

   Intelligence: People with dyslexia are typically of average or above-average intelligence.

   Creativity: People with dyslexia may have strengths in creativity and problem-solving.

   Resilience: People with dyslexia often develop resilience and perseverance due to their challenges.

Figure 1. Dyslexia metrics [6]

3. Diagnosis of Dyslexia from a health perspective

Firstly, to summarize, Dyslexia is a condition that makes it hard for people to read and understand written words. It affects how quickly and accurately they can decode letters into sounds and words. People who are dyslexic may have difficulty decoding speech, recognizing and manipulating basic language sounds, retaining language, and learning letter sounds.

Dyslexia is a brain disorder caused by genetics. People with dyslexia have abnormalities in their brains. The brain is split into two sections: the left part deals with language, and numbers, while the right part handles spatial reasoning [7]. Dyslexia is caused by damage to the left side of the brain's language center, which results in difficulties with reading, writing, and spelling [8].

A dyslexic person has differences in how the brain works and how electrical activity works. Many current ideas look for what causes dyslexia in biology, especially in genes that might make someone more likely to develop it. Some variations in how the brains of individuals with dyslexia and those without learning difficulties function and their anatomical structures have been noted.

Every individual (child or adult) who doubts subjects such as reading, math problems, and focusing should receive an assessment. This assessment is usually carried out in schools, higher education institutions, and psychological counseling. The evaluation should include a comprehensive measurement of reading, spelling, and arithmetic skills. As recent research in the field has shown, an intelligence test or IQ score is not required.

The diagnosis of dyslexia is made by evaluating the child's reading, writing, and pronunciation skills. A speech and language therapist or a special education teacher usually makes the diagnosis. There are several criteria for the diagnosis of dyslexia:

- Assessment of potential familial problems, intelligence level, language ability, word
- Recognition, speaking
- Assessment of language skills
- Recognise and understand words.
- Assessment of speech and reading language skills
- Reading Literacy

- Vocabulary assessment
- Assessing the ability to understand and read new and unfamiliar words.
- To assess the functioning of a person's brain in terms of phonology (pronunciation).

Diagnosis can be facilitated by comparing the results with the survey and test results. If family members also have dyslexia, the suspicion of dyslexia increases. At the same time, the indicators used to diagnose developmental dyslexia involve a range of language challenges. — i.e., accuracy in word recognition and difficulties in fluent speech, poor spelling, and solving abilities — the main focus of research into the pathophysiology of the disorder is on the impact of the language processes. The best-known theories about the workings of auditory speech are:

1. The theory of phonological deficit explores difficulties in processing speech sounds, including their storage, manipulation, and reception.
2. The dual difficulty theory, explores difficulties in both sounding out words and naming objects quickly.

3.1. Electroencephalogram (EEG)

Electroencephalogram (EEG) can detect dyslexia by describing the electrical signals in the brain. These signals are collected through metal electrodes placed on the scalp. EEG measurements can be compared with other techniques like functional magnetic resonance imaging (fMRI) [9]. EEG is a safe and easy-to-use test. The test produces a signal that can be sorted into five categories:

- delta (δ)
- theta (θ)
- alpha (α)
- beta (β) and
- gamma (γ) bands.

The frequency range bands are displayed in Table 1. Currently, in neuroscience and cognitive studies, EGG is widely used as the most effective aid to diagnose and assist in the analysis, observation, and comprehension of the human brain's internal processes.

Table 1. EEG Bands and Description

Bands Type	**Frequency Ranges**	**Bands Description**
Delta (δ)	0-4 Hz	This individuality can be detected during periods of deep sleep.
Theta (θ)	5-7 Hz	It is improved by sleep mode
Alpha (α)	8-13 Hz	Occurs when you feel restless, relaxed, or mentally inactive.
Beta (β)	14-30 Hz	It is noticeable when the mind is attentive
Gamma (γ)	36-40 Hz	The original text lacks context and already adheres to the given principles of simple writing, and complex tasks.

4. Treatment of Dyslexia from a health perspective

In treating Dyslexia, it is necessary to identify the disorder at the very beginning, determine the symptoms of the child's symptoms, and take a path according to the signs. The treatment to be performed depends on the severity of Dyslexia and psychological symptoms or simultaneous disorders. Drug therapy is not helpful for Dyslexia. But if a dyslexic patient has attention deficit hyperactivity disorder (ADHD), medication for ADHD can also improve their ability to learn inside and outside of school.

4.1. Dyslexia treatment methods

The model for Dyslexia includes two causal and two symptomatic levels that overlap over time. Certain techniques and approaches employed to manage Dyslexia comprise.

4.1.1. To propagate reading features

- Change the temperature and color of the text
- Adjust line spacing
- Place highlights and text components

- Text-to-speech reading
- Word guess
- Vocabulary development

4.1.2. To propagate writing features

- Spell check and grammar check
- Word guess
- Vocabulary development
- Writing style improvement

4.1.3. To improve pronunciation skills

- Read aloud
- Pronunciation record
- Feedback

4.2. Other Methods that Are Effective in the Treatment of Dyslexia

4.2.1. The Orton-Gillingham Method in the Treatment of Dyslexia

Samuel Ortan realized in his study that neurological problems that exist in people cause people to confuse letters and create reading problems [10]. Deciphering reading, writing, and speaking as language teaching, Orton has designed an instructional method to establish a connection between symbols and sounds used in colloquial language [11]. In this method, visual, auditory, and dynamic stimuli are put to work simultaneously. In addition to voicing and visually presenting words in teaching, analyzing each sound contained in the phrase individually tracking the spelling directions of letters with fingers can be expressed as one of the program's main features.

In the method, the students first create sound awareness, and each sound contained in the word is analyzed individually. Then, vowel and consonant letters are put to work, and new comments are taught to students. After this stage, syllabic studies are performed, and the writing stage can be started. The points that should be focused on in teaching are instant and abundant feedback, reading speed, and the realization of good reading.

The Orton-Gillingham Method Example:

1. Assume the child wants to be taught the letter 'm'. The letter M is written on the card, and the sound of the letter is made.
2. He then asks the child to make the sound of the letter after going over the letter. It is done again until the child learns the symbol and sound of the letter.
3. After this stage, the child writes the letter in the air and on paper, saying the sound of the letter as they write.
4. Once the child has learned several letters, they are asked to write out deciphered words one letter at a time.
5. Then, words are formed with mixed letters. This step is repeated by forming words with different letters.
6. The printed words are taught to the student by spelling.
7. The words in the book, determined under the teacher's guidance, are read to the student.

4.2.2. The Fernald Method in the Treatment of dyslexia

The development of this method by Grace Maxwell Fernald, is a method for children with dyslexic and excessive reading difficulties, where visual, auditory, mobile, and tactile senses are put to work, which differs from other multisensory methods in terms of teaching words as a whole [12]. The Fernald method, which is incredibly successful by students over the age of 8, helps the child recognize the letters and words necessary for learning to perform reading activities, as well as helps to eliminate inversion errors and symbol confusion during reading over time [13]. This method can be applied in developing reading and writing activities and other courses where students' interest is concentrated [14].

The Fernald Method consists of 4 steps:

1. The word the child chooses is written on paper using a colored pencil. While reading the word, the child is made to follow the talk with his finger by touching the paper. Then, he is asked to write the comment in his notebook by looking at the word written on paper. The process

starts again if the child makes a mistake while watching or writing the word. The situation that should be noted is that the word is always written as a whole.

2. The child reads by looking at the handwritten word and writes from his mind without looking at the word. Correctly spelled words are put into the file alphabetically according to their initials. If he makes a mistake in spelling the word, the first step is repeated. Adding comments to the file continues until a story is created from words. After these operations, the child makes a story with the words he adds to the file and writes the story.
3. In this step, the child has reached the level of learning the words that have been written. For this reason, the process of writing sample words in handwriting is abandoned. The child reads the words he wants to learn by looking at the letters, and then learns by writing. Now he can perform the activity of reading from a book. When there is a word that the child cannot read, it can be helped.
4. In this last step, the child looks at the printed words, repeats them, and can write the comment without looking at the word. He can learn new words from similar terms. The student has now reached a level where he can develop himself.

4.2.3. The Warnke Method in the Treatment of Dyslexia

Recognising the signs of developmental dyslexia has been the main focus of clinical research.The analysis of patient data has helped improve the diagnosis of specific learning problems. This has resulted in the creation of a dependable diagnostic method and useful tools [15]. Creating a comprehensive system to aid and examine kids with developmental Dyslexia has become a significant focus [16].

The technique intends to improve the processing of auditory and visual signals in the central nervous system. It focuses on training the coordination of auditory-motor timing, maintaining balance automatically, and reacting to sound stimuli. These skills are crucial for reading and writing.

4.3. The Brain-Boy Universal Professional (BUMP) Device

Brain-Boy Universal Professional (BUMP) is a tool for testing and improving a child's hearing and vision. It offers activities that children can complete wearing headphones. Based on the findings from the initial assessment, we propose developing a tailored program to meet the child's individual needs and abilities.

The Brain-Boy Universal device is primarily used to enhance skills. The usage plan is determined by the BUP device's evaluation results, which rank the number of games played per session and the level of difficulty. The device features eight games and enables the adjustment of difficulty based on the user's performance.

Central auditory and visual processing can be evaluated through Warnke's method tasks that need specific equipment, like headphones [17]:

1. The Visual Brain-Boy game
2. The Auditory Brain-Boy
3. The Klik-Boy game
4. The Sound-Boy game
5. The Sync-Boy
6. The Speed-Boy
7. The Trio-Boy
8. The Long-Boy game

5. Algorithms and techniques used in diagnostic applications in dyslexia

Many computer applications have been developed to diagnose dyslexia, which has dramatically helped diagnose this disease.

5.1. Dyslexia Diagnosis and Classification System

Research was done in Malaysia, a relatively young nation, with a population of 31.66 million in 2016. 4-10% of students have been found to have signs and symptoms of dyslexia. The University of Malaysia has developed a machine-learning

classification algorithm that helps diagnose dyslexia at an early age. They compiled data from 857 primary school students [18].

5.1.1. The Algorithm

The classification algorithm analyzes the input data and generates an output. As a supervised task, classification needs a predefined target for each sample. The aim is for the algorithm to learn enough to predict and score as closely as possible.

kNN (K Nearest Neighbors Classifier) algorithm was chosen for its better accuracy for this particular data, and supervised learning was used. kNN classifier is best suited for binary classification [19].
There are three categories of machine learning for classification:

- Statistical pattern and recognition [20]
- Machine learning techniques for induction of decision trees or production rules [21][22]
- Connectionist [23]

Python programming language is selected as a tool since it has built-in machine learning algorithms and is open source.

Scikit-learn provides algorithms for machine learning tasks, including classification, regression, dimensionality reduction, and clustering [18]. It also includes modules for feature extraction, data processing, and model evaluation. The user interface of the system is designed using the TKinter graphical user interface in Python.

5.2. Mobile Application to Support Dyslexia Diagnostic and Reading Practice

The main objective of this thesis is to present an application developed to provide dyslexic users with reading exercises to improve their diction of words in the Portuguese language and, on the other hand, as a tool to support health professionals in diagnosing potential cases of dyslexia. Therefore, it can check whether the user's reading follows a predefined set of disadvantages dyslexics commonly face when

reading Portuguese. The verification of the developed tool regards its assertiveness, sound interference, and use with dyslexic people [24].

This application can randomly generate one word at a time for the user to read. The application verifies if the word spoken corresponds to the word presented. A new word is given after five trials if the response is the opposite.

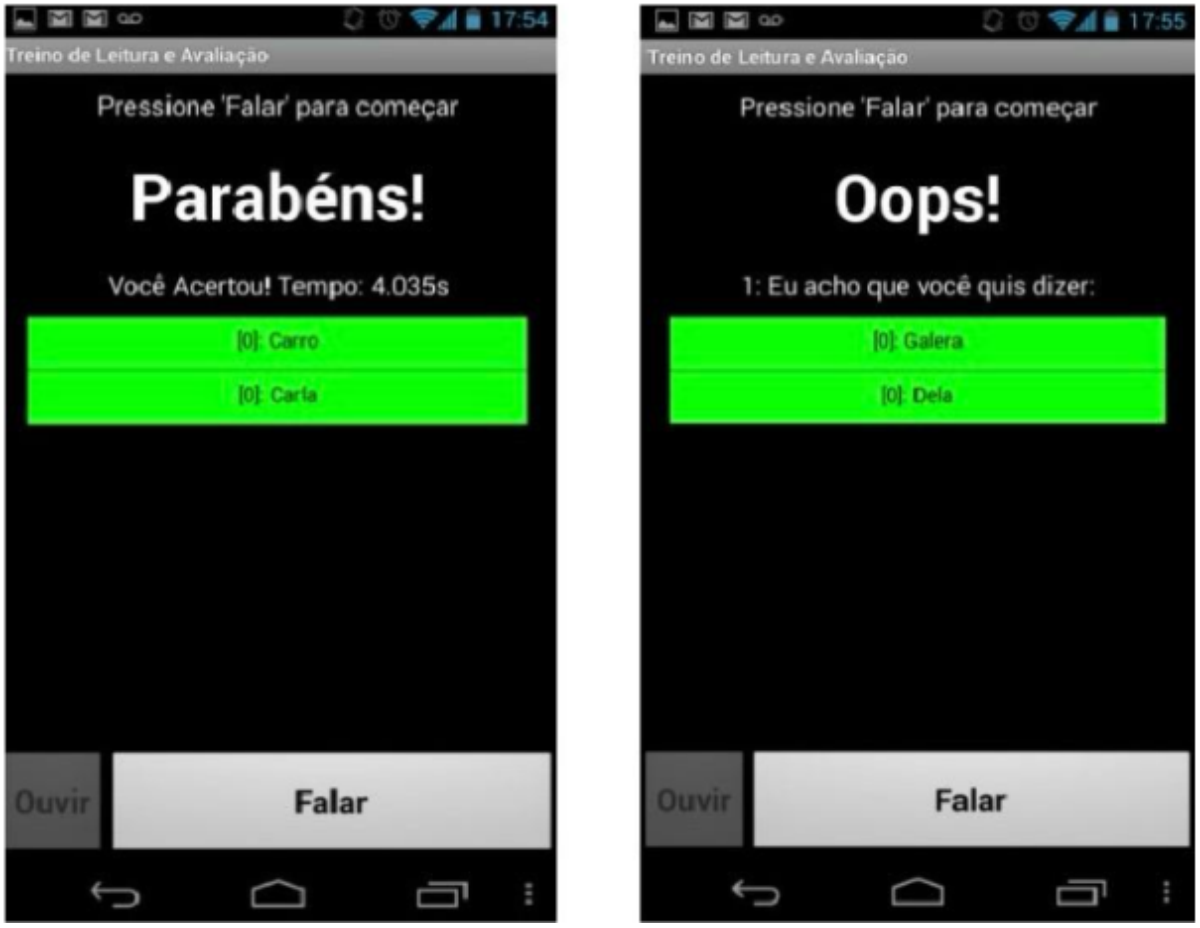


Figure 2. Speaking exercise pages of the application.

The application was developed using a prototyping-based methodology, within which each step was reviewed and incremented. It was initially designed for Android mobile devices, using Android SDK (Software Development Kit) and Java and applying the Nuance voice recognition tool Dragon Mobile SDK (Software Development Kit).

5.3. New Method to Diagnosis of Dyslexia Using 1D-CNN (1 Dimensional Convolution Neural Network)

Electrooculogram (EOG) is one of the methods used to detect eye movements. This study proposed a new method for diagnosing dyslexia. EOG signals were recorded while healthy and dyslexic individuals were reading four different texts prepared in the same font and four different font sizes. Recorded EOG signals were classified using a 1D Convolutional Neural Network for classification [25].

6. Software Applications For Dyslexia Treatment

In the world of mobile applications, developers design various mobile apps to diagnose learning difficulties in children. Furthermore, technological solutions such as mobile devices and artificial intelligence-based assistants have garnered significant interest in addressing these children's educational and learning needs. This review focuses on using artificial intelligence to diagnose individuals with dyslexia, enabling their educational progress through interactive games that cater to their specific needs and the design principles of applications specially crafted for children.

A study of 114 children aged 4 to 7 years provided evidence that children can learn from mobile apps. However, to maintain their interest, these apps should be developed with fresh content, reduced wait times, engaging activities, incentives, goals, and parental involvement [26].

6.1. Machine Learning for the Identification of Dyslexic Individuals

Cognifit developed games for testing dyslexic individuals, as shown in [27, Figure 3] and [28, Figure 4]. Children's accuracy is determined based on their in-game actions. Additionally, these games aim to enhance the areas where children may have deficiencies.

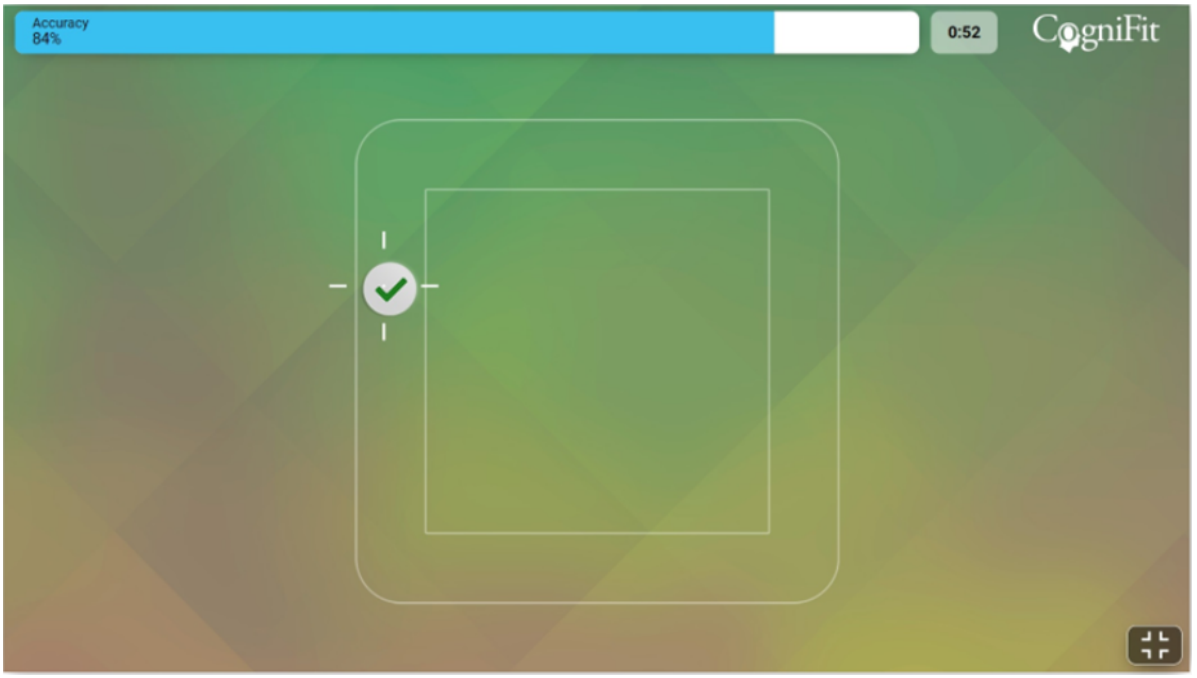


Figure 3. Eye-Hand Coordination Test example with accuracy measured

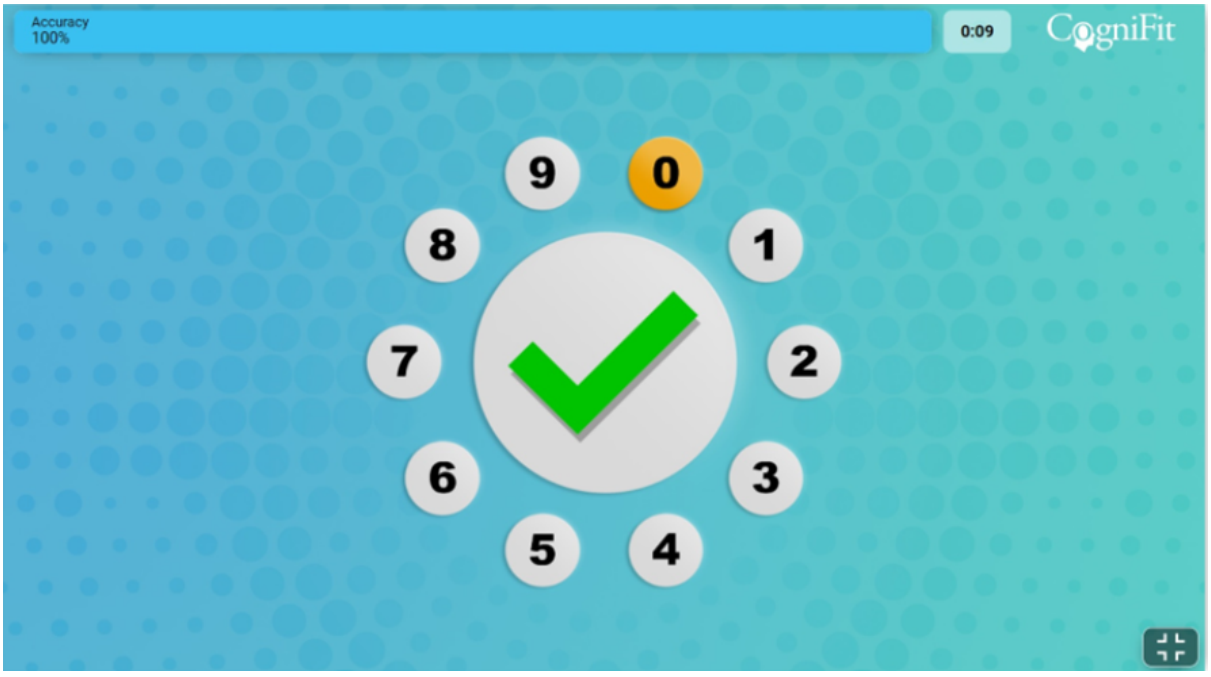


Figure 4. Digit span test example with accuracy measured

6.2. Educational Games for Dyslexic Individuals

Developers design educational games to support the learning processes of dyslexic individuals, aiming to motivate and capture their attention. These games, in particular, should possess the ability to provide customized content for children's education and make the learning process enjoyable. To address the learning needs of dyslexic children, we recommend proposing a software development process model as a solution for creating educational applications. Such models should embrace a user-centered approach, considering the involvement of various stakeholders like teachers, students, psychologists, software engineers, and more [29]. Research indicates that developing educational applications requires different perspectives from stakeholders such as teachers, psychologists, programmers, students, and IT analysts. [30]. Thus, it is crucial to have a software engineering process that integrates analysis, design, development, evaluation, and more.

6.3. Artificial Intelligence-Based Assistants

Artificial intelligence-based assistants aim to provide personalized learning experiences for dyslexic students. These assistants utilize various data sources to determine strategies and tools tailored to the needs and learning styles of dyslexic students. Student surveys, clinical analyses, and other data sources are fundamental in operating artificial intelligence modules. These studies aim to assess the performance and effectiveness of AI-based assistants.

According to a project, artificial intelligence and virtual reality were used to identify the challenges faced by dyslexic students. In preparation for this project, a comprehensive dataset was collected and preprocessed. The first experiment to demonstrate the performance of the proposed artificial intelligence tool used a dataset obtained from Italian universities. This dataset consists of responses from 719 dyslexic students to 52 questions. Among these questions, 12 address various problems caused by dyslexia (comprehension difficulties, writing challenges, concentration issues), 17 investigate the usefulness of specific learning support tools (concept maps, differently colored words), and the remaining 22 explore different

learning strategies and activities for students. The answers to these questions were collected and analyzed using a Likert scale. We evaluated various algorithms such as Random Forest (RF), k-nearest Neighbors (kNN), Support Vector Machines (SVM), and Logistic Regression to determine the best model and configuration for predicting each tool and strategy from this dataset.

When examining the results presented in Table 2 [31, Table 2], we can observe that the top three models with the best performance are SVM Linear with a score of 0.9761, SVM RBF with a score of 0.9633, and kNN with a score of 0.9538 when K=7. On the other hand, the model with the lowest score is again SVM RBF with a score of 0.7246. When evaluating the results, it is evident that the same models yield different scores. As a result, factors such as the threshold value, input type, and data consistency may contribute to different predictions from the same model (SVM RBF). Further analysis is required to determine the precise factors influencing the best results.

Table 2. Best Model to Predict each Support Tool

ID	Best Model	Thr	Input	Cons	Score
T1	SVM RBF	4	Numeric	Yes	0.7443
T2	RF, 50 estimators	4	Numeric	No	0.9433
T3	SVM Linear	1	Binary	No	0.9111
T5	SVM RBF	1	Binary	Yes	0.8852
T6	KNN K=7	1	Binary	No	0.9538
T7	SVM Linear	1	Binary	No	0.9761
T8	KNN K=11	1	Numeric	No	0.9325
T9	SVM RBF	1	Binary	No	0.9298
T10	SVM RBF	1	Binary	No	0.9436
T11	SVM RBF	4	Binary	Yes	0.7246
T12	SVM RBF	4	Binary	Yes	0.7410
T13	KNN K=9	1	Binary	No	0.9449
T14	SVM RBF	1	Binary	Yes	0.9633
T15	SVM Linear	1	Binary	No	0.9354
T16	RF 50 estimators	1	Numeric	No	0.9279
T17	SVM linear	1	Binary	No	0.9367

6.4. Design of Customized Educational Applications

The design of customized educational applications for children facing learning difficulties like dyslexia demands a user-centered approach. People should understand that the level of interest does not solely revolve around entertainment and games; instead, it should be based on the learning perspective in interactive educational aesthetics tailored to a specific age group. Such an environment aims to capture children's attention towards the design of cognitive applications based on their abilities, needs, and learning ease [32]. Application design should align with the age and skills of children and the objectives of the application. User-centered design, especially regarding the user interface design for any cognitive application targeting disabled children, is a fundamental aspect of Human-Computer Interaction (HCI) [33]. The application interface should be user-friendly, focusing on user satisfaction and ease of use.

Research has shown that there are various multimedia cognitive learning applications previously designed. [34, Table 3] presents the main components, frameworks, and algorithms used in these applications for dyslexic children. This table lists the components used in various applications [35].

Table 3.Components used in various applications

Application Name	Features
Dyslexia Baca	Developed in Malaya language, assist alphabet recognition, motivated then to learn and read, repetitive activities of game, reward pages and based of ADDIE model.
MyLexic	Developed in Malaya language, dual coding theory and scaffolding instructional technique has been used and courseware prototype is used
EasyLexia 1.0	Content, activities, course, motivation, word finder games, choose it game, sound finder game, text legible, avoid background stimuli, achievements.
Improve Writing with mobile Application for dyslexia	A mobile app, Writers Learning Algorithm (WLA), text legible, significant multimedia elements, avoid background stimuli. User profile, the progress of the user.

According to research, applications emphasize content and educational software over user interface design. If the flow of the designed application is user-friendly and motivates the user to interact with the system enjoyably for cognitive learning, learning outcomes can be improved [36].

6.5. Example of Applications

6.5.1. Dyslexia Quiz

The software application facilitates a comprehensive understanding of the impact of dyslexia on children aged 5-11 in an engaging manner. It proves exceptionally advantageous for parents and educators seeking insights into the experiences of children with dyslexia. The 4-minute test incorporated within the application encompasses 50 potential symptoms of dyslexia. The application effectively illustrates the ramifications of dyslexia on a child's performance in reading, writing, memory tests, and planning. These activities

help children discover how many symptoms of dyslexia they have. [37, Figure 5] displays the interfaces of the Dyslexia Quiz application.

Figure 5.a. Introduction and reading exercise page of the application

Figure 5.b. The writing and memory exercise page of the application

Figure 5. 'Dyslexia Quiz' application interfaces

6.5.2. Reversals For Dyslexia

It is an application that includes activities based on preventing confusion of letters such as b-d, p-d-b, and numbers 6-9, which are common symptoms of dyslexia, and reducing these problems. Within the application, users can choose between letters or numbers and engage in activities where they can flip them vertically or horizontally. [38, Figure 6] displays the interfaces of the Reversals For Dyslexia application.

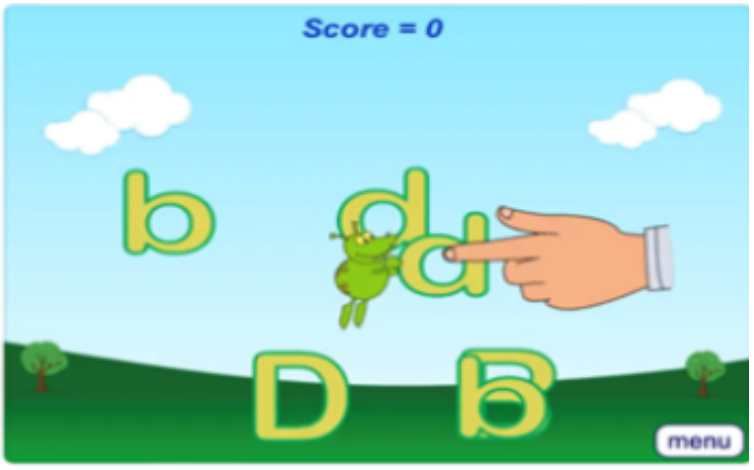


Figure 6.a. Game example of the application

Figure 6.b. Game example of the application

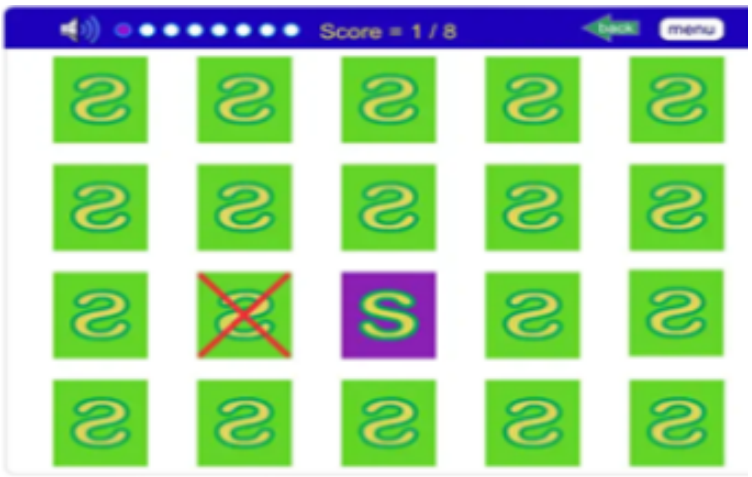


Figure 6.c. Game example of the application

Figure 6. Reversals For Dyslexia application interfaces

6.5.3. Smartex Akıllı Alıştırmalıklar (EN: Smartex Smart Exercises)

Developers created the application to address neurological issues such as dyslexia, dysgraphia, dyscalculia, and speech-language disorders. It incorporates activities such as letter matching, picture matching, word puzzles, and auditory puzzles, allowing users to listen, comprehend, and match. The application aims to address the challenges faced by children with this type of neurological disease through games, which are tailored based on the child's performance. The application is ad-free and free. Gains provided by the application:

- Development of Phonological Awareness Skills
- Development of Attention and Focus Skills
- Development of Visual Perception Skills
- Development of Reading and Writing Skills
- Development of Auditory Perception Skills
- Development of Optical Discrimination Skills
- Development of Mathematics Skills
- Development of Articulation Skills
- Development of Language and Speech Skills
- Development of Memory Skills

Smartex Smart Exercises application interfaces are given [39, Figure 7].

Figure 7.a. Smartex Application Main Page

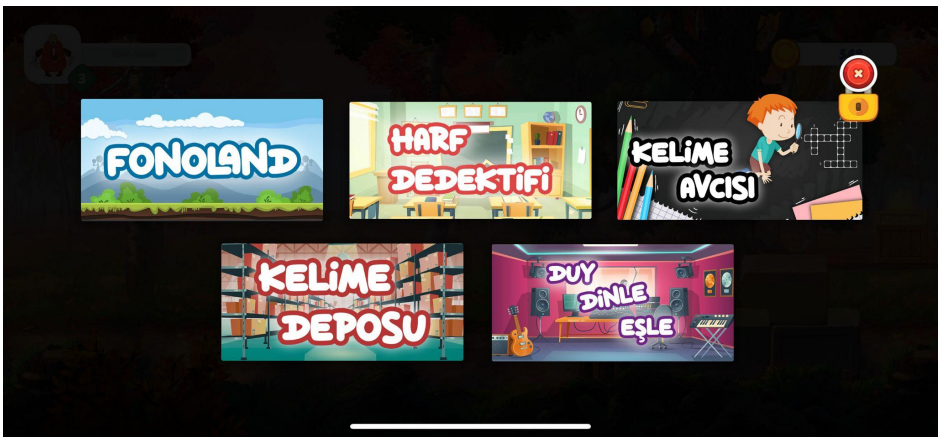


Figure 7.b. Game in dyslexia (TR: Disleksi) part of application

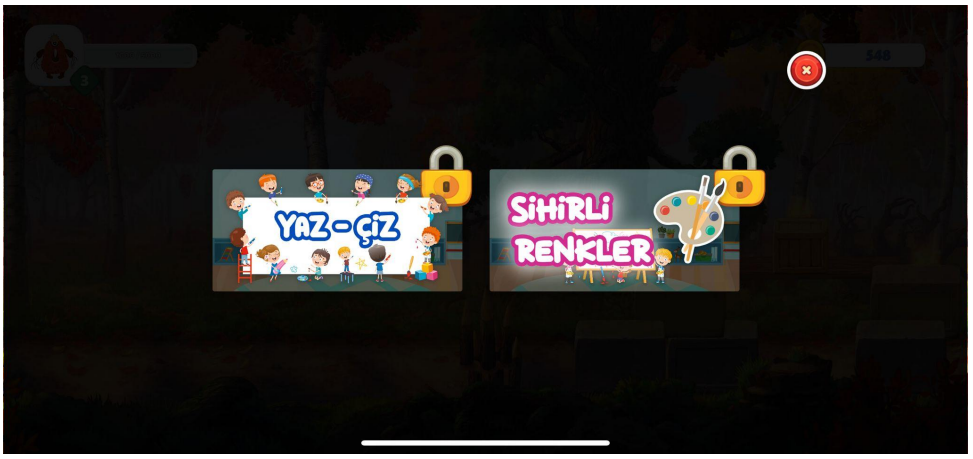


Figure 7.c. The games in the dysgraphia(TR:Disgrafi) part of the application

Figure 7.d. The games in the dyscalculia(TR: Diskalkulia) part of the application

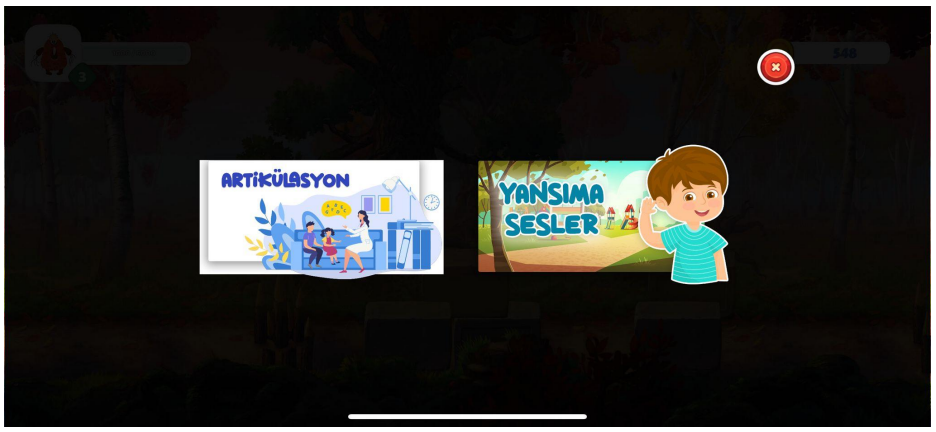


Figure 7. e. The games in the dyscalculia(TR: Diskalkulia) part of the application

Figure 7. Smartex Smart Exercises application interfaces

6.5.4. Dyslexia AI

The application's design aims to enhance the reading and spelling skills of children with dyslexia. The application puts children to the test with unique games. These games include features such as categorizing words according to their phonetics, making sounds of words, and artificial intelligence-supported voice recognition, and the rewards won from the game are displayed with augmented reality. [40, Figure 8] illustrates the interfaces of the Dyslexia AI application.

Figure 8.a. Text & Speech part of the application

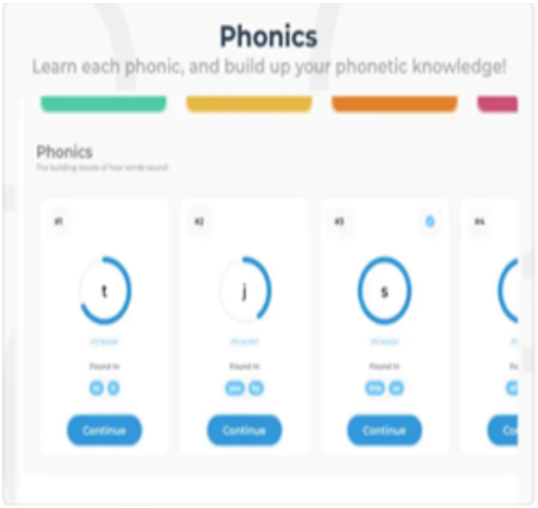


Figure 8.b. Phonics part of the application

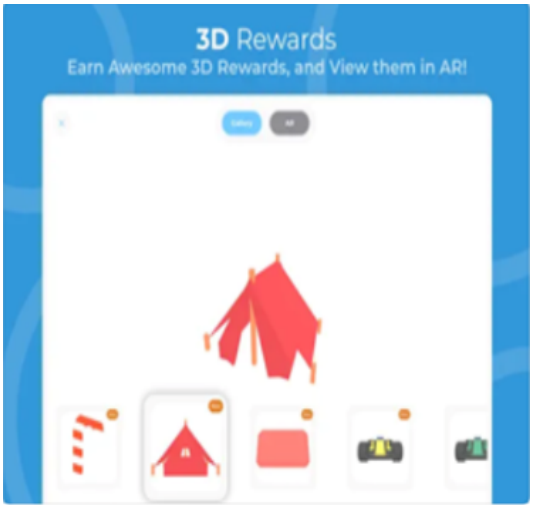


Figure 8.c. 3D Rewards part of the application

Figure 8. Dyslexia AI application interfaces

6.5.5. Auto Train Brain

The first software was the dyslexia application called AutoTrainBrain, developed by Günet Eroğlu, a PhD student at Sabancı University. Believers argue that using this software increases children's reading speed and reduces the likelihood of errors. AutoTrainBrainde completed the testing process with 100 individuals and received support from TÜBİTAK. The statement mentions that the annual subscription fee is $250. [41, Figure 9] displays the Auto Train Brain application interfaces.

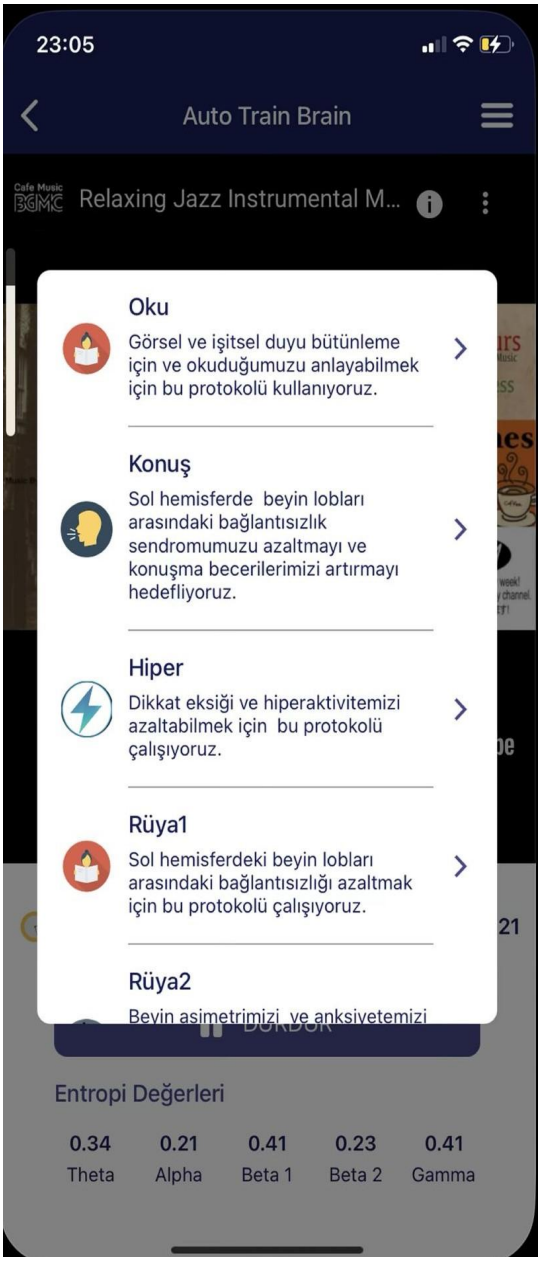


Figure 9.a. Information protocols used in the application

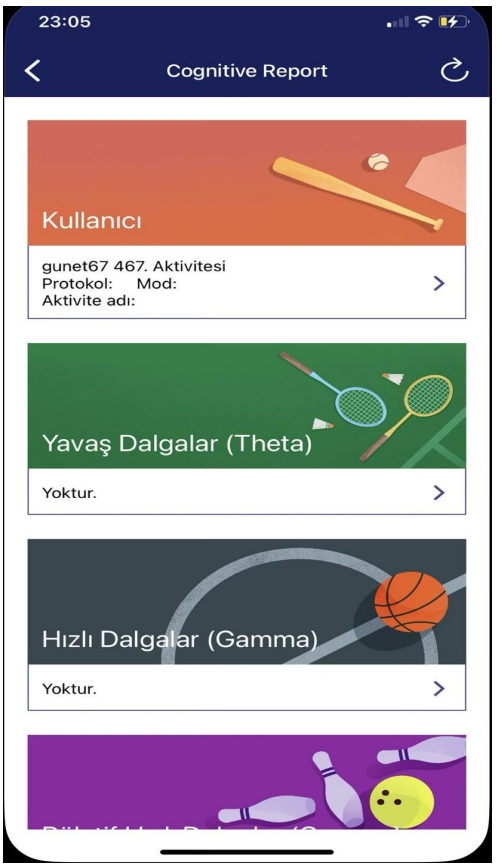


Figure 9.b. Application Cognitive report section

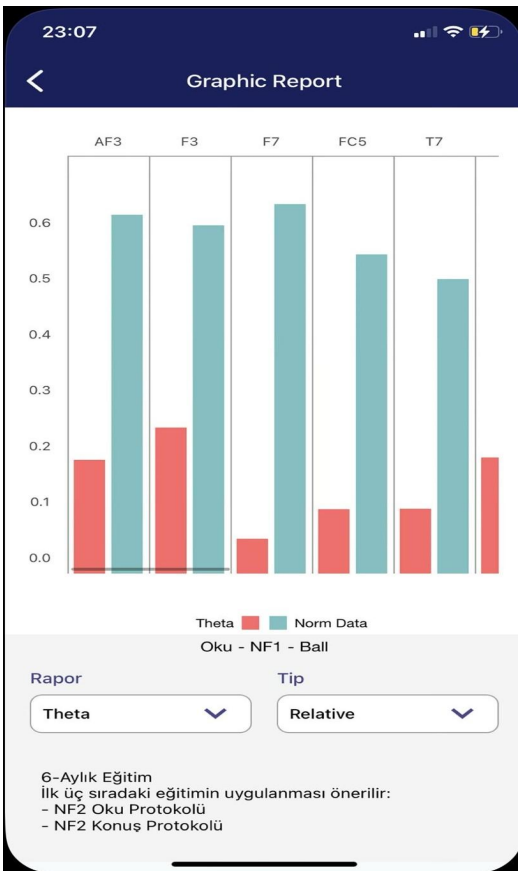


Figure 9.c. Application Graphic report section

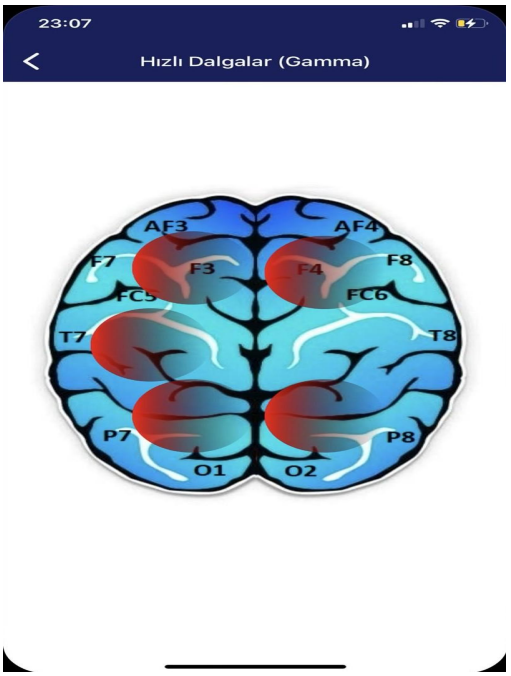


Figure 9.d. The results of the tests performed are shown in the brain

Figure 9. Auto Train Brain application interfaces

6.5.6. Read&Write Gold

Texthelp developed Read&Write Gold, an easy-to-use software that users can access from a computer or phone. It attempts to alleviate dyslexia and other learning disabilities by reading text typed on the screen or any text aloud. It increases the individual's self-confidence by reading bold or double-colored areas aloud with the add-ons available in the application. If we count the features it includes, these are Listening to Speech by Reading Text, Guessing/Filling in Words, and Translating Words. It is a type of software that is easy to install and start using. [42, Figure 10] illustrates the interfaces of the Read&Write Gold application.

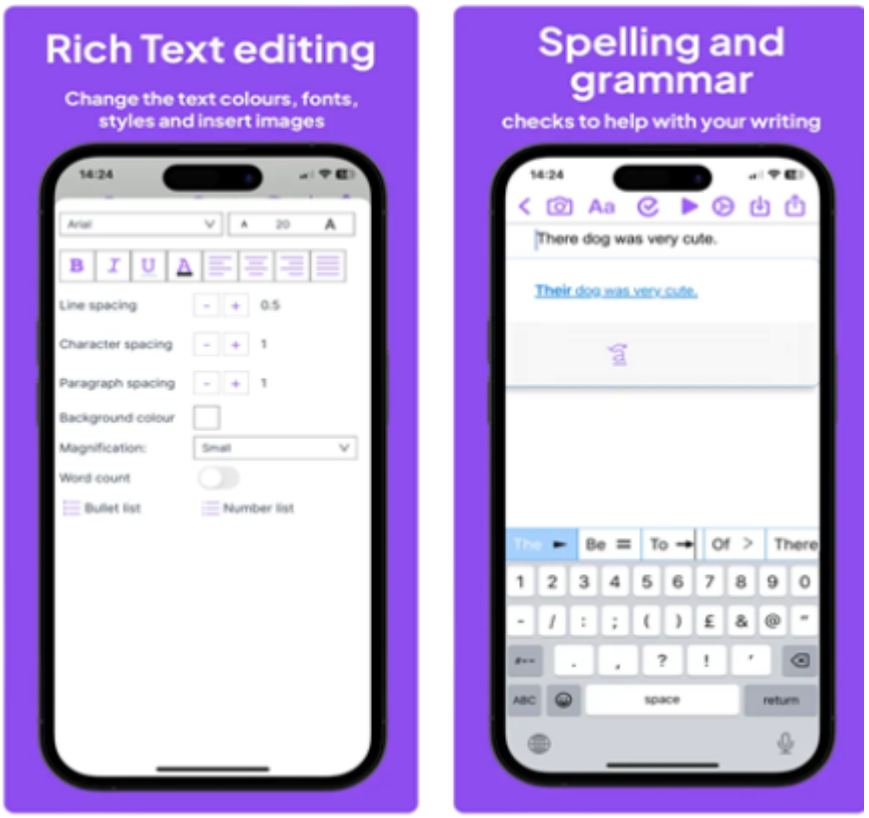


Figure 10.a. Rich text editing Spelling & Grammar Part of Application

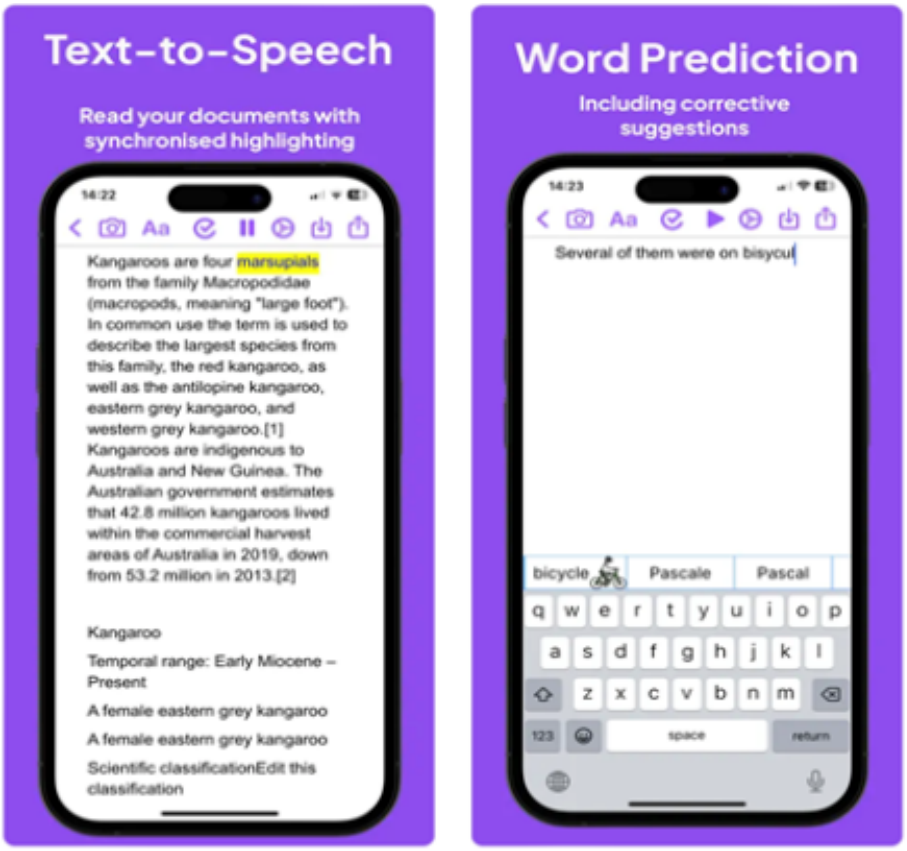


Figure 10.b. Speech-to-Text & Word Prediction Part of Application

Figure 10. Read&Write Gold application interfaces

6.5.7. Speechify

It is a software application that can help people with dyslexia and others with ADHD, autism, and other learning disabilities. Through the translation of text into speech and the highlighting of text, the application enhances the perception of letter sounds. It promotes focused attention on words, thereby facilitating improved fluent reading. The incorporated software enables enhanced text comprehension, fostering an increased interest in reading. This software application, compatible with most browsers, is accessible and usable at no cost. [43, Figure 11] displays the interfaces of the Speechify application.

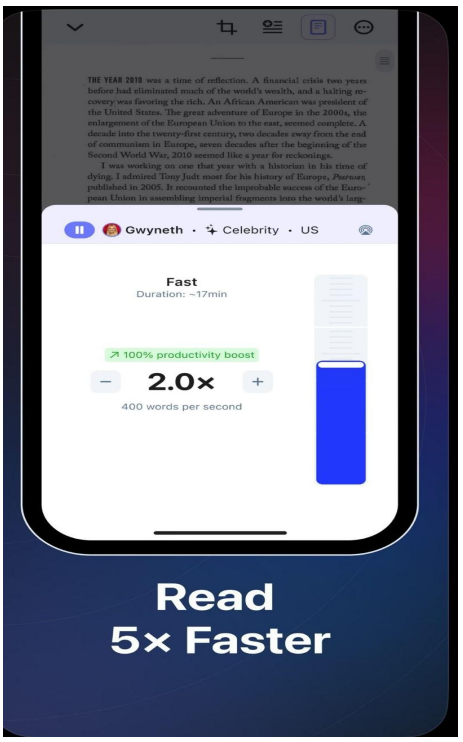


Figure 11.a. The effectiveness of measuring and improving the reading speed of the application

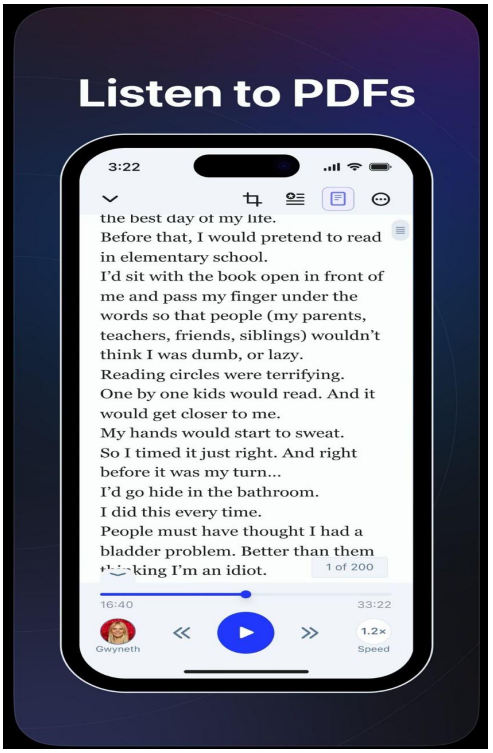


Figure 11. b. Listening and reading exercise

Figure 11. Speechify application interfaces

6.5.8. Dyslexia Quest

This application, which targets children between the ages of 5-11, helps overcome dyslexia with game-based tests. Developed at the Bristol Dyslexia Center, the software is accessible via the browser without downloading. Under adult supervision, it completes a game called Elimination Yeti Mountain within 20 minutes, without children realizing they are in a test, thus determining whether the child is at risk of dyslexia. In [44, Figure 12], the Dyslexia Quest application displays its interfaces.

Figure 12.a. Application number sorting game

Figure 12.b Application character matching game

Figure 12. Dyslexia Quest application interfaces

6.5.9. Yazı Sihirbazı (EN: The Writing Wizard)

The software application facilitates writing style editing and enhances writing speed by passing over letters, words, or sentences with one's finger. This application is free for download on Google Play for ages 5-11. [45, Figure 13] illustrates the interfaces of the Yazı Sihirbazı application.

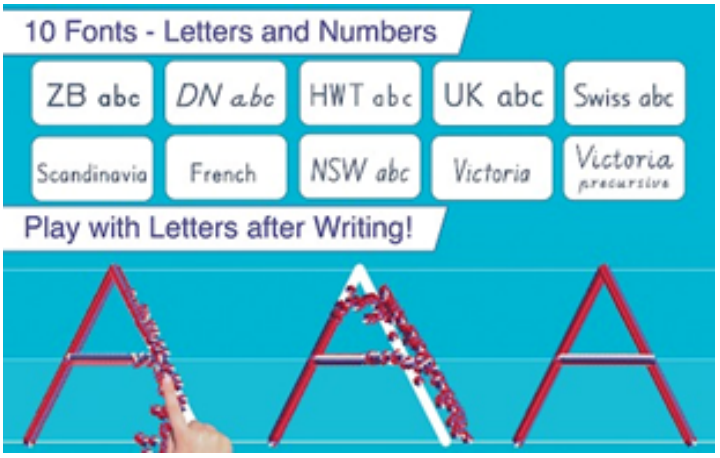


Figure 13.a Matching activity by typing numbers and letters

Figure 13. b Finding the right word according to the number of letters of the word

Figure 13. Yazı Sihirbazı application interfaces

6.5.10. Simplex Spelling Light

Designed to enhance writing and reading skills in a fun and interactive way, it utilizes 'Reverse Phonics'. The prevention of word memorization in over 1000 languages, coupled with the facilitation of fluent speech through spelling and repetition with provided clues, comprises vital features of this application. A success message is displayed upon the correct pronunciation of a word, encouraging users to attempt to find the correct word with hints. This software application, exclusively available on IOS, is downloadable and usable at $4.99. [46, Figure 14] displays the interfaces of the Simplex Spelling Light application.

Figure 14. Simplex Spelling Light application interfaces

7. Conclusion

The study examined the effects of dyslexia on children in general and the diagnosis and treatment of dyslexia. Researchers have examined which software tools are typically used to diagnose and treat dyslexia. The study describes the diagnostic and treatment aspects of dyslexia in two different areas: health and software. Researchers examined the methods used to diagnose and treat children with dyslexia and standard techniques. Researchers examined the software used to diagnose and treat dyslexia and the projects that have been developed to date. Researchers have conducted many studies on dyslexia in children. These reviews have helped us learn more about the disorder in both software and healthcare, and our work has helped you better understand what dyslexia means.

Software Requirements Specification

1. Introduction

1.1. Purpose

This document comprehensively describes the Dyslexia Diagnosis and Educational Game System. It will explain the system's objectives, features, user interface, what the plan is built for, and how it will be constrained to operate and respond to external stimuli. This system aims to improve children's intelligence and help early diagnosis of dyslexia. This document aims for both the stakeholders and the developers of the system.

1.2. Scope of Project

The Dyslexia Diagnostic and Educational Game System is designed for children at least four years old with dyslexia. The system will be developed to provide parents with a practical and accessible tool for early diagnosis of dyslexia in their children, making this diagnosis very easy and inexpensive. The system will help educate dyslexic children about the disease through educational games (s). Essentially, the scheme aims to reduce the financial barriers associated with diagnosing dyslexia, improving the efficiency of the diagnostic process and reducing associated costs.

1.3. Glossary

TERM	DEFINITION
WCAG	Web Content Accessibility Guidelines
2FA	Two-Factor Authentication
IOS	iOS is a mobile operating system filed by Apple.
UML	UML is a standard modeling language for visually designing and understanding systems, software, and business processes.
Actor	Users, roles, or other systems interacting with and existing outside the system are essential components.
UC	They are functions or goals that actors can achieve using the system.
Database	It is the structure where the system stores and manages its data.
System	It represents the software or business process boundaries where usage scenarios within applications and games occur.
Simon Task	It is a test of attention and reaction time. It is a test that has visible or colored stimuli in different positions and measures its accuracy.

2. General Description

2.1. System Environment

The "Dyslexia Diagnosis and Educational Game System" is designed for children aged four and above with dyslexia. The system also considers parental profiles. Its primary goal is to provide an effective and accessible tool for early dyslexia diagnosis, making the process easy and cost-effective. Additionally, the system aids in alleviating dyslexia through educational games tailored for dyslexic children.

2.2. User Characteristics

The primary user base includes children aged four and above, focusing on those diagnosed with dyslexia. Additionally, parents are considered users for monitoring their children's progress within the system. An administrator with special privileges is also included to address user and system-related issues.

2.3. General Constraints and Assumptions

2.3.1. Constraints

- The system targets children aged four and above
- The games should be user-friendly and engaging for children.

2.3.2. Assumptions

- Users have access to a device with the necessary hardware capabilities.
- Users are familiar with basic interactive interfaces.
- Parents oversee and assist their children's interaction with the system.

3. Specification Requirements

3.1. Interface Requirements

3.1.1. User Interface

The user interface of the application will be simple and user-friendly. This application will be in a web application and mobile application type. When the user enters the system, a Main page will greet him, and he must make two choices. The first choice leads to a page for preliminary diagnosis and is presented with a test consisting of games, at the end of which accuracy and knowledge are suppressed. The second selection is the Educational games section. In this part, accuracy should be increased by giving a certain number of lives in the games so that the user can improve their skills.

3.1.2. Hardware Interface

It is compatible with devices commonly used by children, such as tablets or computers.

3.1.3. Software Interface

Responsive and adaptable software for different devices. Admin interface for system management.

3.1.4. Communication Interface

Online communication for user login and data storage.

3.2. Functional Requirements

3.2.1. Diagnostic System

The system will allow users to access a diagnostic page to obtain information based on performance results in various games for a preliminary diagnosis of dyslexia. The system will provide a total average accuracy score and score-related preliminary information based on the user's performance in different games.

3.2.2. Diagnostic Games

The system will provide a variety of diagnostic games to evaluate different cognitive abilities. The first of these games is a letter-matching game for letters and reading skills. The second game is a Navigation game inspired by Simon Task. The third and last game is the symmetry game to measure people's visual problems. Each game will include a mechanism to measure the user's accuracy and provide feedback at the end of all games.

3.2.3. Educational Games

The system will offer educational games designed to develop specific skills or areas of knowledge. Educational games will include progress tracking to show the user's progress over time.

3.2.4. Navigation

The system will offer intuitive navigation between games and system pages. Users can quickly return to the home page from any game or diagnostic tool.

3.2.5. Accuracy Tracking

The system will monitor the accuracy of user responses in diagnostic and educational games. It will store accurate data to track user progress and provide analysis.

3.2.6. Admin Controls

The system will provide an admin panel with maintenance and user support tools.

3.2.7. Platform Compatibility

The system will be compatible with multiple platforms, including desktop and mobile devices.

3.2.8. Responsive Design

The system will use a responsive design to adapt to various screen sizes and orientations. Interactive elements will be accessible and usable on all target devices.

3.2.9. Exit and Return

Users can exit the games and return to the main menu whenever they want. The system will save the game state so users can return and continue where they left off.

3.2.10. Efficiency and Cost Reduction

The system will be designed to optimize resource usage to minimize operating costs. It will implement efficient data processing and storage to ensure fast loading times and reduce server costs.

3.2.11. User Account Management

The system will allow users to create accounts, log in, and recover forgotten passwords. Users will be able to view profile information.

3.3. Non-Functional Requirements

3.3.1. Performance

The system should provide a smooth and responsive experience by responding to user interactions within a reasonable time frame (2 seconds or less).

3.3.2. Scalability

The system should be designed to handle increasing users and content without significant degradation in performance.

3.3.3. Reliability

The system must be stable and reliable, minimize downtime (Azure's average uptime (availability time) for overall services is stated to be 99.928 percent), and ensure that users can access the platform consistently.

3.3.4. Usability

The user interface should be intuitive, with straightforward navigation and easy-to-understand instructions, ensuring a positive and frustration-free user experience.

- Intuitive interfaces and straightforward navigation should meet users' goal of accessing desired features in 3 clicks.
- There must be a maximum of 1 click target to access the main menu and submenus.
- During any action, the number of clicks required for users to return to the previous step should be 1.
- Important information (such as help, support, and terms of use) should be accessible in 2 clicks from the home page or any page.

3.3.5. Accessibility

The system must comply with accessibility standards to ensure it can be used by people with different abilities, including those with visual, auditory, or motor disabilities. Must be 99.9% compliant with WCAG 2.1 AA standards such as keyboard usage, timing adjustability, readability, and clarity.

3.3.6. Security

Robust security measures should be implemented to protect user data and ensure the privacy and confidentiality of sensitive information. User data is encrypted for privacy—secure login and authentication mechanisms with data encryption, 2FA.

3.3.7. Compatibility

The system should be compatible with various devices, browsers, and operating systems, enabling users to access it from various platforms.

- She/He supported Browsers and Devices: For example, the two latest versions of Chrome, Safari, and Firefox, and the three latest versions for iOS(17.2.1 and above) and Android(Android 14.2.1 and above).
- Screen Resolutions: Adaptive design that can decode at least 95% of the most common screen files.

3.3.8. Interoperability

The system should integrate with other educational platforms, tools, or systems that schools, educators, or parents may use.

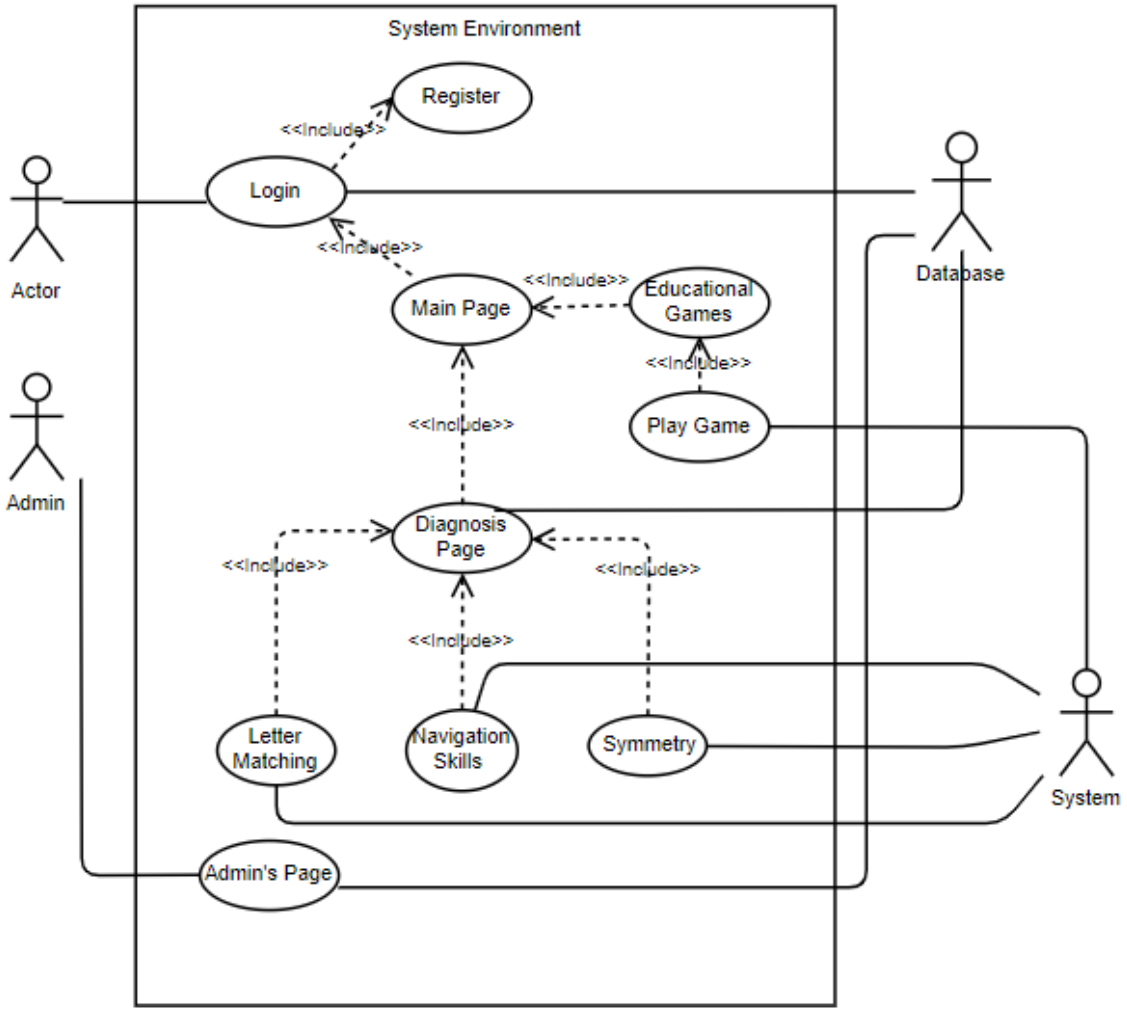
3.3.9. Ethical Considerations

The system should be designed and operated ethically, considering the well-being and rights of the users, particularly children.

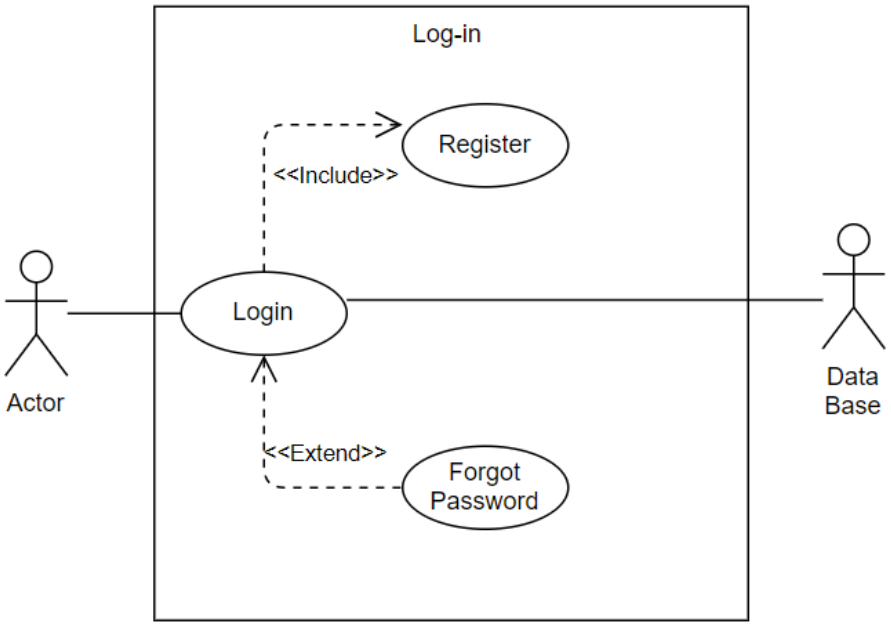
4. Analysis- UML

4.1. Use Cases

4.1.1. System Use Case



4.1.2. Login Page Use Case

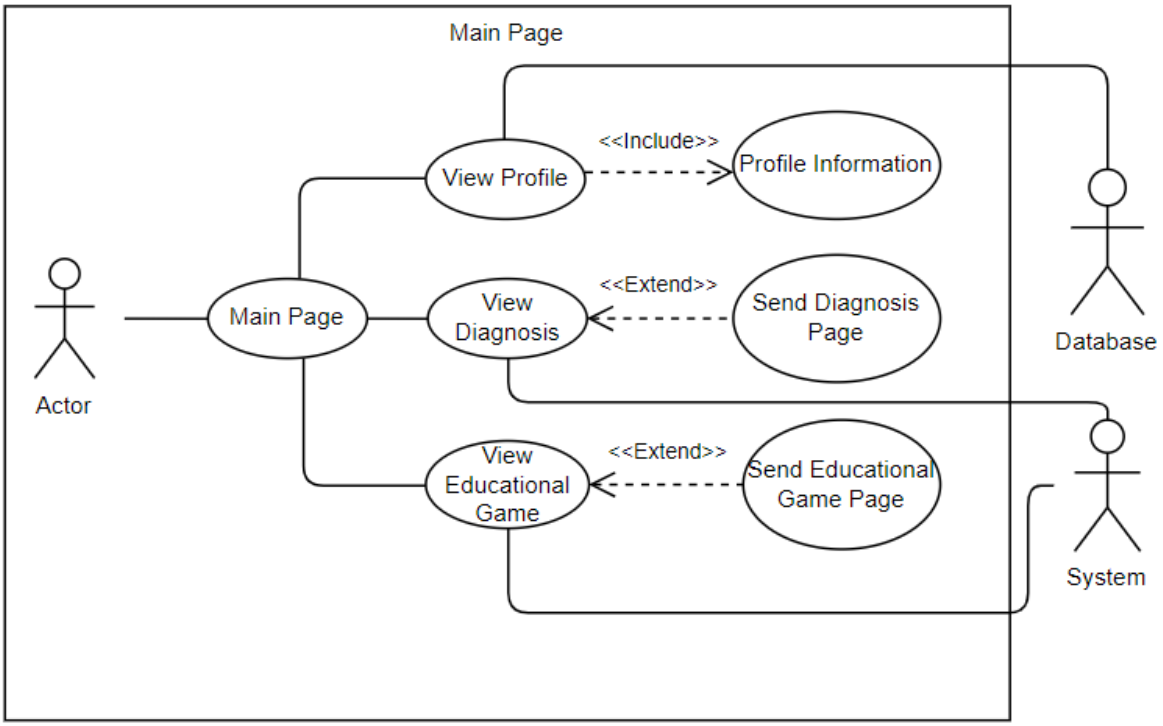


Use Case Number	UC-1
Use Case Name	Login Page
Actor	Actor, Database
Description	The user logs into the application using their email and password. The user can click the Forgot Password link if the password cannot be remembered. If the user is not registered, they are prompted to go to the Register page.
Precondition	The user must have the application open and be on the login page.
Scenario	1. The user opens the application and is presented with a login page. 2. The user enters his/her email and password. If the login attempt fails, he/she can reset their password. 3. If he/she is a new user, go to register.
Postcondition	The user successfully logs into the application and is directed to the Main Page, begins the password reset process, or is directed to the registration page.
Exceptions	Possible exceptions include entering an incorrect password, a failed login attempt due to a system error, or trying to log in with an email that is not registered.
Related Use Cases	UC-2, UC-3

Use Case Number	UC-2
Use Case Name	Register
Actor	User, Database
Description	The user goes through the registration process to create a new account, which includes providing personal details and setting up login credentials.
Precondition	The user has launched the application and chosen to register a new account.
Scenario	1. Upon registering, the user is prompted to enter the necessary information (name, surname, email, password). 2. The information is submitted to the application for account creation.
Postcondition	If the registration is successful, the user is taken to the Login Page.
Exceptions	The registration process might only be successful if the user provides valid details, an account with the provided email already exists, or if there is an error during the registration process.
Related Use Cases	UC-1

Use Case Number	UC-3
Use Case Name	Forgot Password
Actor	User, Database
Description	The user initiates a password reset process to regain access to their account.
Precondition:	The user must be on the Login page and have already tried to log in or selected the "Forgot Password" option directly.
Scenario	1. The user selects "Forgot Password". 2. Input their email address. 3. Follow the steps, typically including receiving a password reset link via email. 4. Create a new password and confirm the change.
Postcondition	The user has successfully reset their password and is automatically redirected to the Login page.
Exceptions	Potential exceptions include the system not recognizing the email address. The user cannot access their email account; alternatively, a system error prevents the password reset process from being completed successfully.
Related Use Cases	UC-1

4.1.3. Main Page Use Case



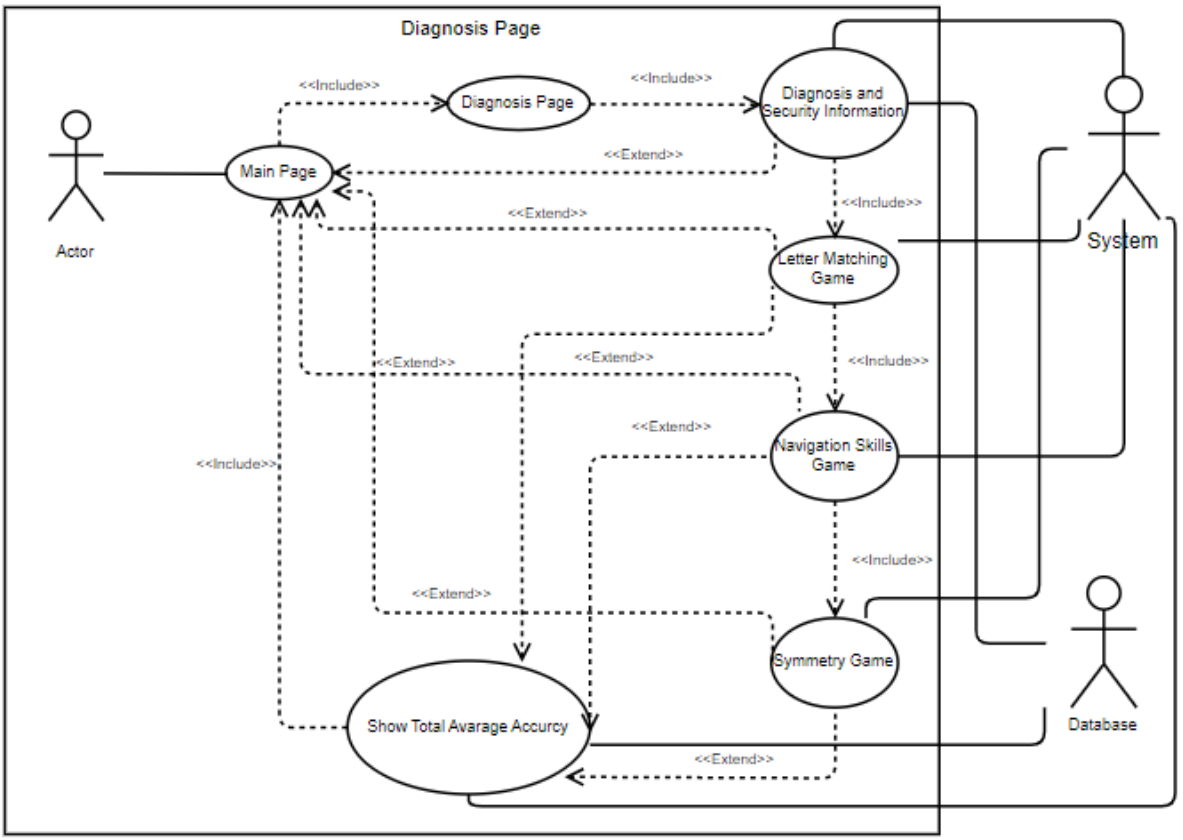
Use Case Number	UC-4
Use Case Name	Main Page
Actor	User, System
Description	The user views the application's main page to access the profile, diagnosis, and games. (The user accesses the Main Page to navigate to Profile, Diagnosis, or Educational Games.)
Precondition	The user must be logged in to access the Main Page.
Scenario	1. After the user logs in, the user is presented with the Main Page. 2. User can choose to view their profile, access the diagnostic tool, or select educational games designed to help with dyslexia. 3. The selected page is displayed.
Postcondition	The user successfully navigates to one of the three options and is engaged with the selected functionality.
Exceptions	Errors may occur if the user is not logged in or if a system error prevents the Main Page from displaying correctly. Additionally, an error will prompt if the user attempts to access the diagnostic tool or educational games without proper permissions.
Related Use Cases	UC-5, UC-6, UC-7

Use Case Number	UC-5
Use Case Name	View Profile
Actor	User, Database
Description	The user can view their profile within the application. This typically includes personal information, diagnostic results, and other relevant data stored in the profile.
Precondition	The user must be logged into the application and located on the Main Page.
Scenario	1. The user selects "View Profile". 2. Retrieves and displays the system's profile information.
Postcondition:	The user's profile information is readable and presented to him/her orderly.
Exceptions	Warn when profile information cannot be accessed or there is an error retrieving profile data from the database
Related Use Cases	UC-4

Use Case Number	UC-6
Use Case Name	View Diagnosis
Actor	User, System
Description	It directs the user to the main diagnostic page within the application, making it easier to access diagnostic information. The diagnostic page can provide preliminary diagnostic results, historical data, and recommendations based on the user's specific preliminary diagnosis of dyslexia.
Precondition	The user must be logged in and present on the application's Main Page.
Scenario	1. The user selects the "Preliminary diagnosis" option on the Home Page. 2. The system directs them to the primary diagnosis page, where they can see detailed information about the dyslexia diagnosis and start testing.
Postcondition	The user is redirected to the diagnostic page, where he can interact with the diagnostic information, better understand his condition, and access relevant functionalities or recommendations provided by the application.
Exceptions	If there is a problem navigating the system or the diagnostic page fails to load, it will issue an error to try again.
Related Use Cases	UC-4

Use Case Number	UC-7
Use Case Name	View Educational Games
Actor	User
Description	Allows users to access the application's Educational Games from the Home Page. It is the first stage in the process of a user navigating games designed to help dyslexia.
Precondition:	The user must be logged in and present on the application's Main Page.
Scenario	1. The user clicks on "View Educational Game" on the Home Page. 2. The system directs the user to the Educational Games Home page.
Postcondition:	The user enters the Educational Game section and can browse, select, and interact with the available games.
Exceptions	The Educational Games section cannot be accessed due to system problems or an error when loading game content.
Related Use Cases	UC-4

4.1.4. Diagnosis Page Use Case

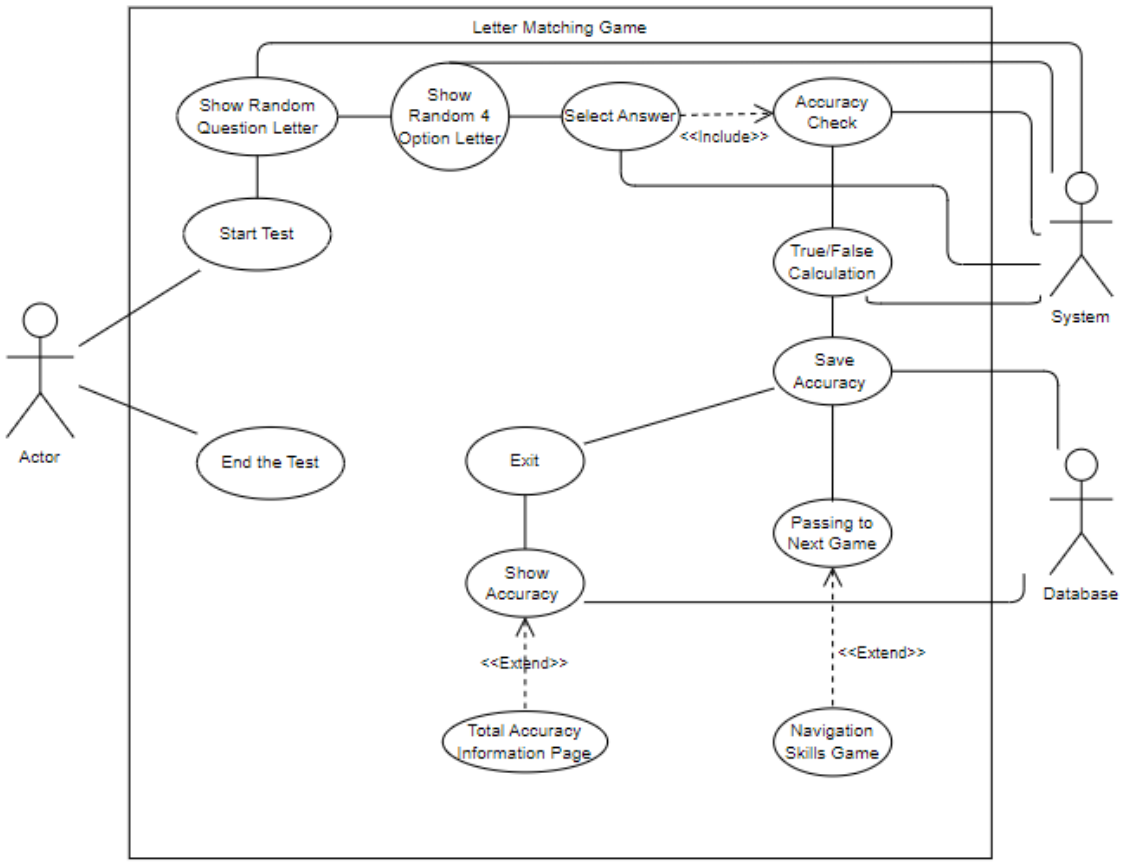


Use Case Number	UC-8
Use Case Name	Diagnosis Page
Actor	Actor
Description	The user uses the main page to access the diagnosis page. The user can access the diagnosis and security information page on the diagnosis page. The user clicks “ Start Diagnosis” and then plays the first Diagnosis game. After completing each game, the user's average accuracy is calculated and displayed.
Precondition	The user must be logged in to access the Main Page.
Scenario	1. The user navigates to the diagnosis page from the main page. 2. The diagnosis page displays information about the user's diagnosis. 3. The user navigates to the diagnosis and security information page. 4. The diagnosis and security information page is displayed. 5. The user starts the first game. 6. The game is launched. 7. The game is completed. 8. Accuracy is calculated and displayed.
Postcondition	The user receives their total average accuracy after completing all games and can navigate back to the Main Page.
Exceptions	If a game is not completed or there is an error in displaying accuracy, the user may not receive the total average accuracy.
Related Use Cases	Main Page, Letter Matching Game, Navigation Skills Game, Symmetry Game

Use Case Number	UC-9
Use Case Name	Diagnosis and Security Information
Actor	Actor, System, Database
Description	The User reaches the Diagnostics Page after selecting "View Diagnostics" on the Home Page. This page provides information about the preliminary diagnostic test and data security. It provides a start button to start the test or an exit option to return to the Main Page.
Precondition	The user must be logged in and access the Main Page. You must have clicked the View Diagnosis button on the Main Page
Scenario	1. The user selects “View Diagnostics”. 2. Show information and options to start or exit the test.
Postcondition:	The user starts the diagnostic test or returns to the Main Page.
Exceptions	The user may decide not to continue testing.
Related Use Cases	UC-4, UC-11

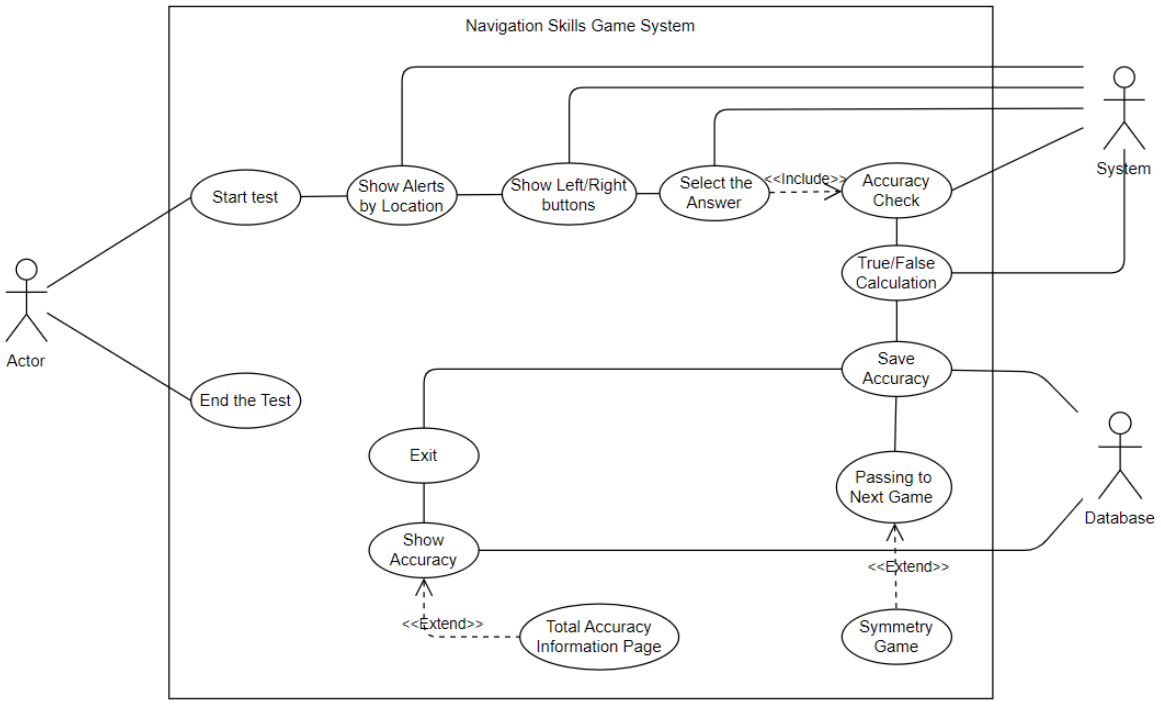
Use Case Number	UC-10
Use Case Name	Show Total Accuracy and Information
Actor	Actor, System, Database
Description	After completing the third game, the user is automatically directed to the information page where the overall average accuracy and a preliminary diagnosis based on percentage accuracy are provided.
Precondition	The user may have completed the Letter Matching game and the test. The user may have completed the first two games (Letter Matching and Navigation Skills) and finished the test. The user may have completed all three games (Letter Matching, Navigation Skills, and Symmetry Game).
Scenario	1. The user presses the finish test button. 2. The user is given the Total Accuracy Average and Information. 3. When the user clicks exit, the user returns to the Main menu.
Postcondition	The user receives the overall average accuracy and preliminary diagnosis with the option to return to the Home Page.
Exceptions	The user may exit the game before the second and third games are completed.
Related Use Cases	UC-4

4.1.4.1. Letter Matching Game Use Case



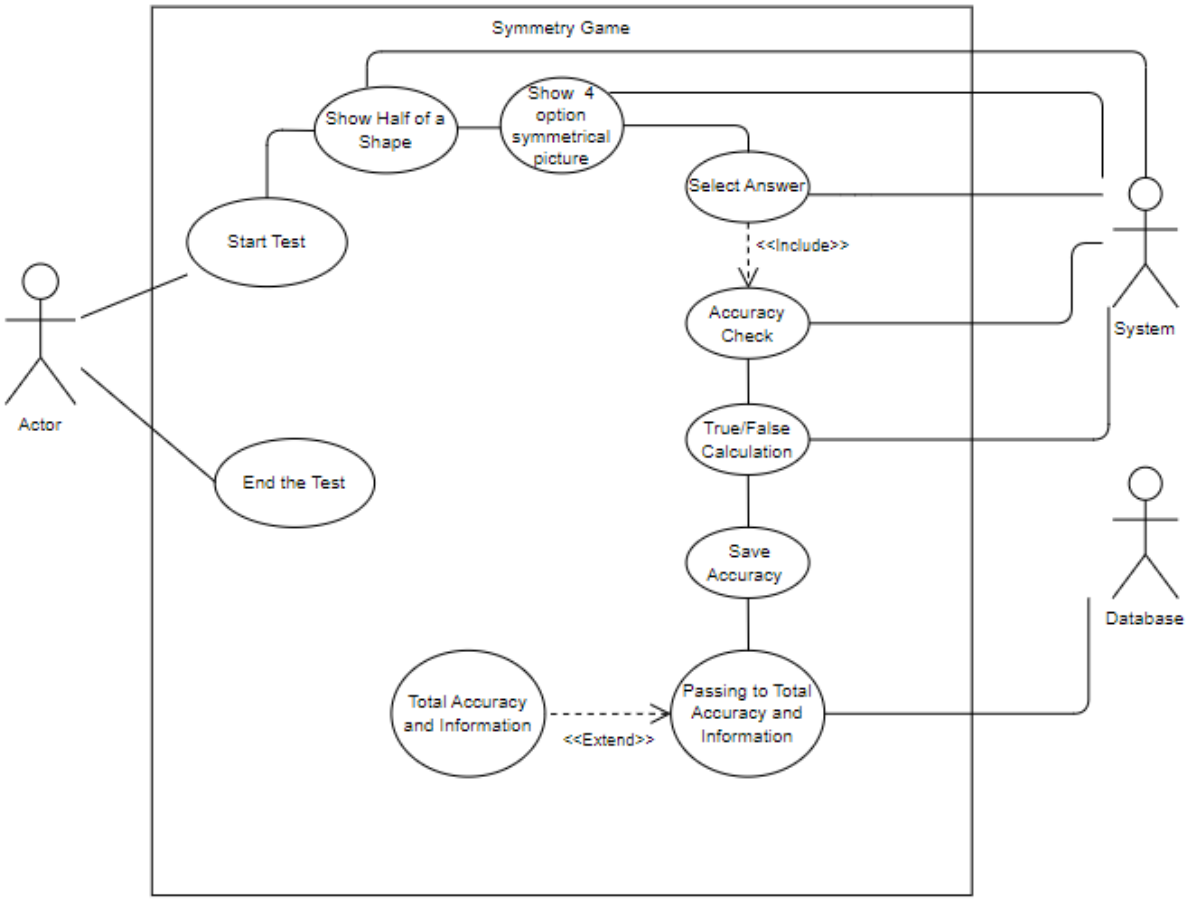
Use Case Number	UC-11
Use Case Name	Letter Matching game
Actor	Actor, System, Database
Description	The user enters a game where they are shown a random letter and must choose the correct match from four options. Accuracy is calculated after all game options have been completed. The user can then choose to move on to the next games or view total accuracy average information and exit the Main Page.
Precondition:	The user can start this game “In Diagnosis Page” after completing the diagnosis information stage.
Scenario	1. The user starts the game. 2. Choose each letter shown and complete the game.
Postcondition	After completing the game, users can choose to proceed to the next game (Navigation Skills Game) or view detailed accuracy information and return to the Main Page.
Exceptions	The user can choose to exit at any time. The user will receive an Error message if a technical issue affects the game.
Related Use Cases	UC-4, UC-10, UC-12

4.1.4.2. Navigation Skills Game Use Case



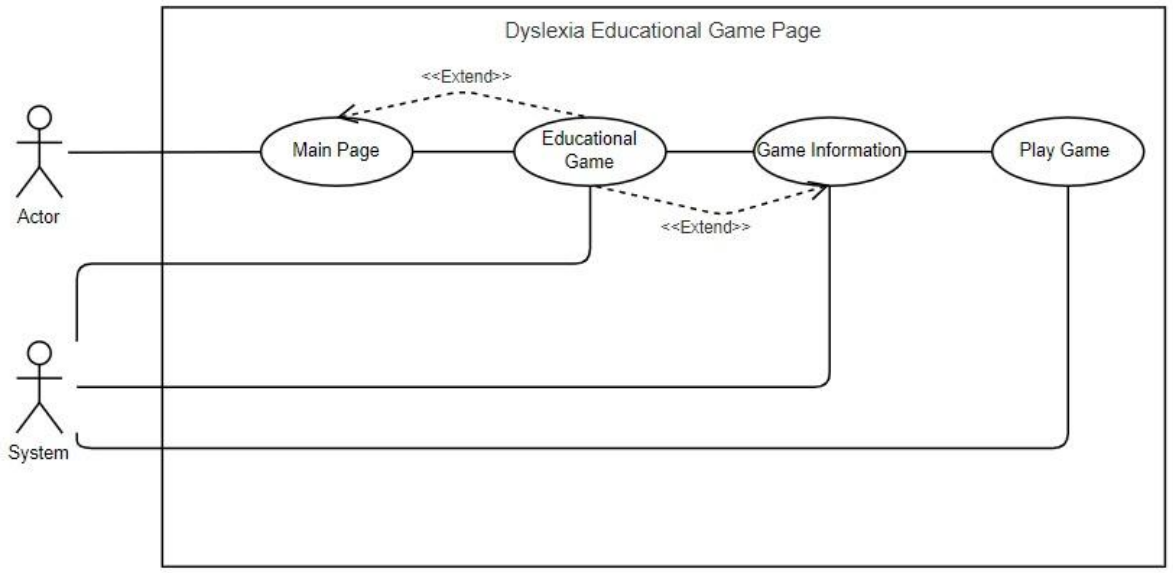
Use Case Number	UC-12
Use Case Name	Navigation Skills Game
Actor	Actor, System, Database
Description	The user uses the system to improve navigation skills through a game that tests their ability to follow directions and respond to alerts.
Precondition	The user must log in to the system and play the Letter Matching game.
Scenario	1- The user starts the test. 2- The system displays alerts based on location. 3- The system shows left/right buttons for selection. 4- The user selects the answer. 5- The system performs an accuracy check. 6- The system calculates true/false and saves accuracy. 7- The user may exit the test or proceed to the next game.
Postcondition	The user's accuracy is recorded in the system. The user can view their accuracy or proceed to the next game.
Exceptions	The User selects the wrong answer; the system fails to record the response; the user exits before completion.
Related Use Cases	UC-10, UC-13

4.1.4.3. Symmetry Game Use Case



Use Case Number	UC-13
Use Case Name	Symmetry Game
Actor	Actor, System, Database
Description	The user will try to find the correct symmetrical half to match the picture box provided at the top of the screen in one of the four options given below.
Precondition:	The user must log in to the system and play the Letter Matching and Navigation Skills games.
Scenario	1. Symmetry Game displays a picture box at the top of the screen. 2. Four random image boxes appear at the bottom of the screen. 3. The User selects one of four options. 4. The system checks whether the selected option is the correct symmetrical match. 5. After the game, it directs the user to the total accuracy and information page.
Postcondition	After completing the game, view detailed accuracy information and return to the Main Page.
Exceptions	The user can choose to exit at any time. The user will receive an Error message if a technical issue affects the game.
Related Use Cases	UC-4, UC-10

4.1.5. Educational Game Page Use Case

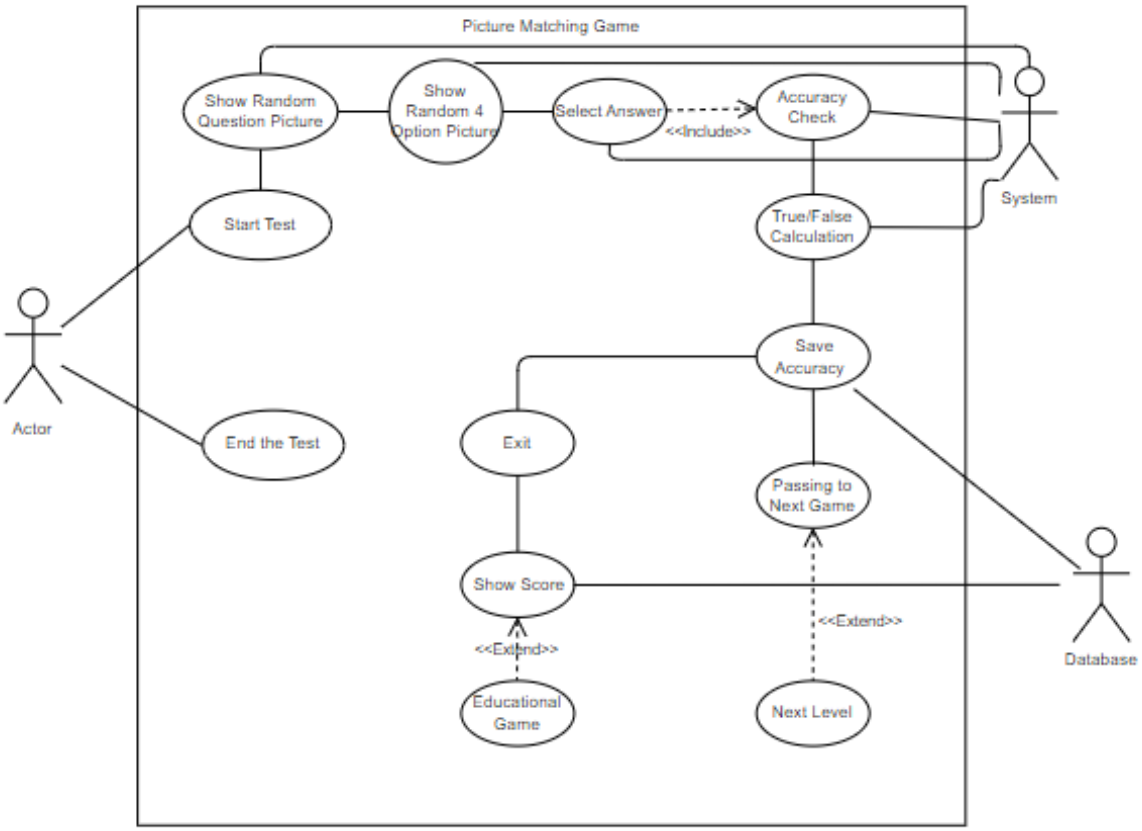


Use Case Number	UC-14
Use Case Name	Educational Game
Actor	Actor, System
Description	After the child user logs in to the system, he goes to the game section and chooses the game he will play. Before the game starts, an informative window opens, and the user must agree to start the game.
Precondition	The user must log in to the system and be directed to the home page.
Scenario	1. The user logs into the system 2. The user clicks on the game box 3. The user selects a game 4. The user will be presented with an information page before entering the game. 5. If the user accepts, the system starts the game; if the user rejects it, it returns to the game selection. 6. If the user clicks the exit button, he returns to the home page.
Postcondition	The user is either playing a game, browsing the game selection, or returning to the home page.
Exceptions	If the user tries to go to the game section without logging in, they will be asked to log in.
Related Use Cases	UC-1, UC-14, UC-15

Use Case Number	UC-15
Use Case Name	Game Information
Actor	Actor, System
Description	This page explains how to play the selected game, provides rules and objectives, and offers a "Start Game" button to start the game or an "Exit" button to return to the previous page.
Precondition	The user has gone to the Educational Game section and selected a specific game to explore.
Scenario	1. The user selects a game. 2. The Game Information page opens. 3. The user is informed about the instructions and rules of the game. 4. He decides to start playing by clicking the "Start Game" button or to return to the Educational Game list by clicking the "Exit" button.
Postcondition	The user either starts playing the game or returns to the list of educational games to select a different option.
Exceptions	An error occurs if a system failure prevents the Game Information page from displaying correctly or if certain game information is unavailable for any reason.
Related Use Cases	UC-14, UC-16

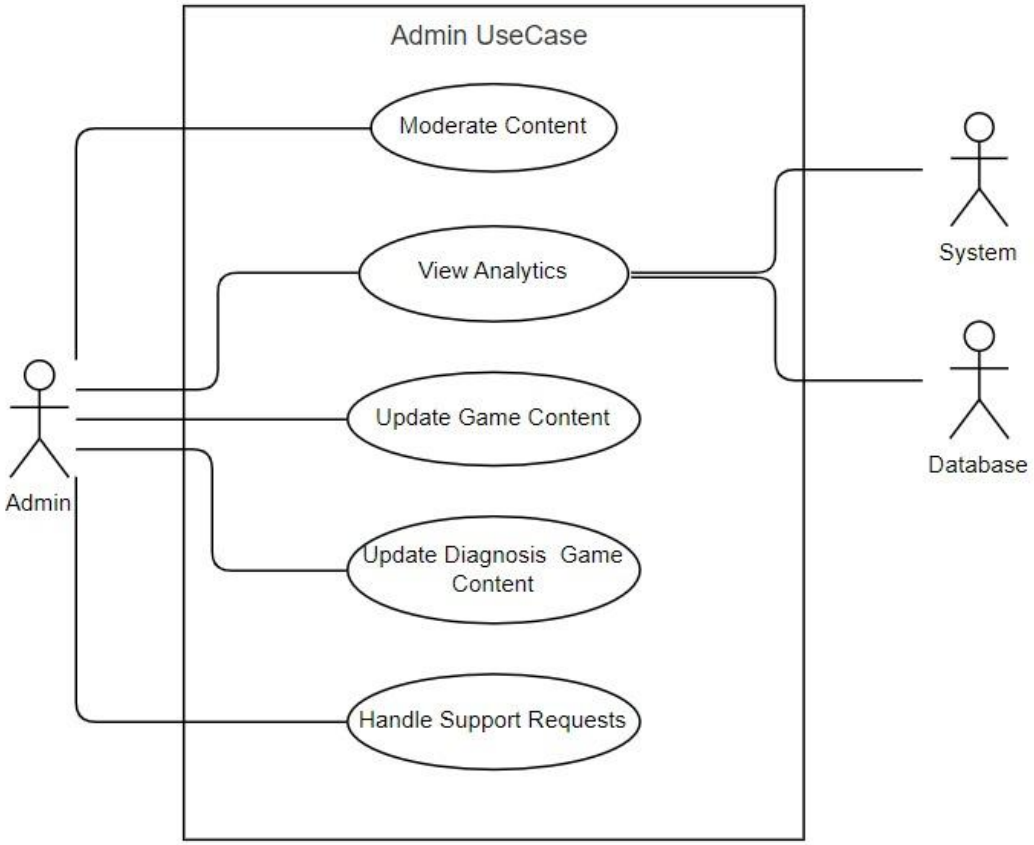
4.1.5.1. Play Game Use Case

4.1.5.1.1. Picture Matching Use Case



Use Case Number	UC-16
Use Case Name	Picture Matching Game
Actor	Actor
Description	The User plays a game where they must match a random picture with one of four options presented, aiming to improve memory and recognition skills.
Precondition	On the educational game page, the user must select the game and press the start button.
Scenario	1. Show a random image to the user. 2. The system displays four random images as possible matches. 3. The system gives the user three wrong rights. If the user chooses three wrong options, the game ends, or the restart button is activated. 4. The user selects the image they believe matches the original. 5. The system checks if it is correct. 6. The game can move on to the next level or exit if the user reaches the correct answers the system determines.
Postcondition	The user receives feedback on their choice and chooses to continue or exit another game.
Exceptions	The user may want to quit while in the game or may receive an error while in the game.
Related Use Cases	-

4.1.6. Admin Use Case



Use Case Number	UC-17
Use Case Name	Admin’s Main Page
Actor	Admin, System, Database
Description	This use case encompasses all the activities an Admin can perform on the main page of the system, including content moderation, analytics review, game content updates, diagnosis game content updates, and handling support requests.
Precondition	Admin must be authenticated and authorized to access the main admin page and its functions.
Scenario	Admin logs into the system with admin credentials. The system directs the Admin to the main page dashboard. Admin chooses an activity from the dashboard: Moderate Content, View Analytics, Update Game Content, Update Diagnosis Game Content, or Handle Support Requests. Admin completes the chosen activity using the system's tools and interfaces. The system processes the changes or updates made by the Admin. The system updates the Admin with the status of the activity and logs the action. Admin logs out or chooses another activity.
Postcondition	The system reflects any changes or updates made by the Admin, maintaining data integrity and ensuring that all user interactions are logged.
Exceptions	If the Admin attempts an unauthorized activity, the system restricts access and logs the attempt. If there is a system error during any activity, the system notifies the Admin and logs the error. If incorrect data is submitted, the system rejects the changes and requests the Admin to correct the data.
Related Use Cases	All specific use cases under the Admin main page (Moderate Content, View Analytics, Update Game Content, Update Diagnosis Game Content, Handle Support Requests) are interrelated as part of the Admin's responsibilities.

Use Case Number	UC-18
Use Case Name	Moderate Content
Actor	Admin
Description	The administrator monitors and moderates user-generated content to maintain community standards.
Precondition	Admin is authenticated and has the necessary permissions.
Scenario	1. The administrator reviews user submissions. 2. Flags or remove inappropriate content. 3. It warns users when necessary. 4. Communicate problems to the legal team when necessary.
Postcondition	Game content is safe and complies with community guidelines.
Exceptions	Include failure to detect some types of inappropriate content and user disputes.
Related Use Cases	UC-20

Use Case Number	UC-19.
Use Case Name	View Analytics
Actor	Admin, Database
Description. The	Admin reviews game analytics to make informed game updates and community management decisions.
Precondition	Analytics tools are operational and accessible. Admin is authenticated and has the necessary permissions.
Scenario	1. Admin logs into analytics dashboard. 2. Select desired metrics 3. The system interprets data patterns and trends. 4. Generates reports for stakeholders.
Postcondition	Admin has the information needed for decision-making.
Exceptions	Analytics tools down, data corruption.
Related Use Cases	UC-18, UC-20

Use Case Number	UC-20
Use Case Name	Update Game Content
Actor	Admin
Description	The Admin updates the game's content to provide new features, bug fixes, or enhancements to the players.
Precondition	Admin is authenticated and has the necessary permissions.
Scenario	1. Admin logs into the admin portal. 2. Select the content update section. 3. Uploads new game assets or edits existing ones. 4. Submits changes for review. 5. Publish the updates to the game.
Postcondition	Game content is successfully updated.
Exceptions	Upload fails, incorrect file format, unauthorized changes.
Related Use Cases	UC-18, UC-19

Use Case Number	UC-21
Use Case Name	Update Diagnosis Game Content
Actor	Admin
Description	Admin updates diagnostic tools and scripts in the game to ensure proper functioning and to fix any identified issues.
Precondition	Admin has logged in with sufficient privileges.
Scenario	Admin accesses the diagnostics section. Review current diagnostic tools and scripts. The system implements updates or corrections when necessary. Tests the updated diagnostics.
Postcondition	Diagnostic tools are up to date.
Exceptions	Diagnostics fail, and updates are not compatible.
Related Use Cases	Handle Support Requests.

Use Case Number	UC-22
Use Case Name	Handle Support Request
Actor	Admin
Description	Admin reviews and responds to user support requests submitted through the system.
Precondition	Admin must be logged in and have access to the support request dashboard.
Scenario	1. Admin logs into the system. 2. Admin navigates to the support request dashboard. 3. Admin selects a support request from the queue. 4. Admin reviews the request details. 5. Admin takes appropriate action to resolve the request. 6. Admin updates the support request status 7. Admin communicates the resolution to the user.
Postcondition	The support request is resolved, and the user is informed of the resolution. The support request status is updated accordingly.
Exceptions	If the admin cannot resolve the request, it is escalated to a higher level. If the support request details still need to be completed, the admin contacts the user for more information.
Related Use Cases	UC-4, UC-10

Software Design Description

1. Introduction

1.1. Purpose

This Software Design Document is intended for the project “Dyslexia Diagnosis Tests and Educational Games,” an inclusive digital solution aimed at diagnosing and supporting children with dyslexia at four or older years old. The primary goal of this document is to provide a detailed plan for the design and development of the software. It will serve as a guide for the development and a reference for stakeholders to understand the project's design development and implementation strategies clearly.

Dyslexia, a widespread disease affecting reading, writing, and spelling, is often misunderstood and underdiagnosed. Dyslexia is complex; it varies significantly in its presentation, making it difficult to identify with only observation. It changes differently from person to person, influenced by various factors, including language, age, and education. Due to those facts, there is a widespread lack of understanding and numerous misleading conclusions about dyslexia. Many still see it as just a reading disorder, ignoring its impacts on learning and cognition.

In addition, professional diagnosis of dyslexia can be costly. It often contains comprehensive assessments by psychologists, educators, or speech-language therapists. In many regions, especially low-income areas, access to tools capable of diagnosing dyslexia is limited. Parents must travel long distances, adding to the overall cost and difficulty of obtaining a diagnosis.

Schools may lack the resources or trained personnel to identify and support students with dyslexia effectively. Without a proper diagnosis, students with dyslexia often are unsuccessful in their academic lives, and that leads to long-term educational and social consequences.

The aim of our Dyslexia Diagnosis Tests and Educational Games is to facilitate all these problems by giving children two types of games, one for diagnosing dyslexia and the second for increasing their skill development. Diagnosis involves

engaging in three innovative and child-friendly tests: Letter Matching, Navigation Skills, and Symmetry. Those tests will test children's cognitive and linguistic abilities related to reading, writing, and directional knowledge. For skill improvement, a Picture Matching Game will be available. This game is designed to address specific challenges faced by children with dyslexia. After children play the diagnosis game, depending on their score, accuracy will be calculated and shown on the screen. The accuracy will tell parents whether their children are at risk of having dyslexia disease.

This document outlines the software's overall structure, including the high-level architecture, data flow, user interface design, and algorithm for diagnosis and educational activities. It also addresses critical factors such as security, privacy, and compliance with relevant academic and health standards.

This implementation of "Dyslexia Diagnosis Tests and Educational Games" will provide a significant advancement in educational technology, offering an efficient tool for early dyslexia detection and intervention.

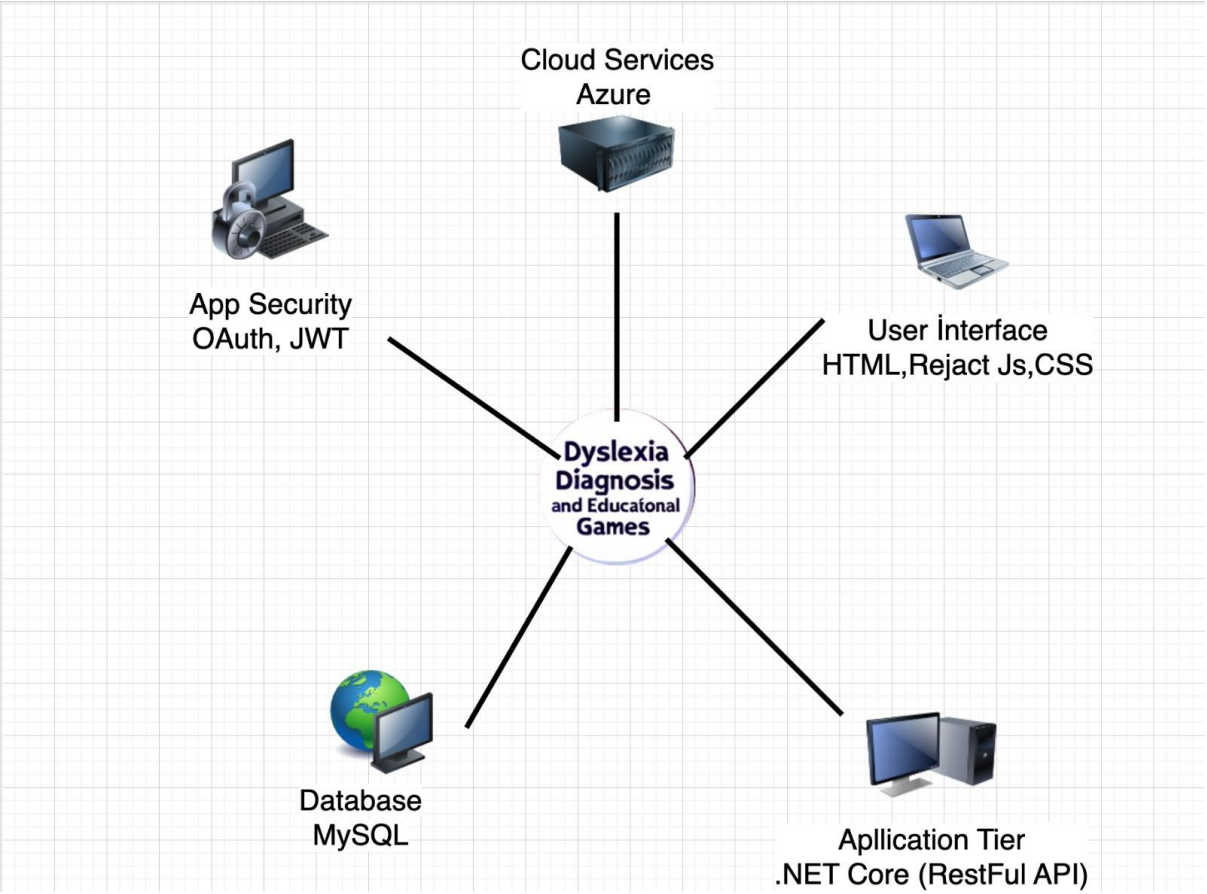
1.2. Scope of Project

This document contains a complete description of the design of "Dyslexia Diagnosis Tests and Educational Games." While using the application, the user is expected to log in. After login, a child-friendly screen with two options will be provided—one for dyslexia diagnosis tests and one for educational games. Letter Matching Test is a test that tests the children's reading abilities. The test will show four random letters and an answer letter, and the children will choose the correct letter among the four random letters. Navigation Skills Test is a test that tests the children's directional knowledge. The test will display alerts based on location and left/right buttons for selection. The children will try to go to that location using the left/right buttons. The Symmetry Test is a test that tests the children's visual abilities. The test will display four random pictures and one answer, and the children will choose the correct symmetrical match.

1.3. Overview of the software architecture

The software architecture for "Dyslexia Diagnosis Tests and Educational Games" is designed to support its dual functionality of dyslexia diagnosis and educational gameplay. MySQL database, a widely used open-source relational database management system known for its reliability, ensures consistency in the app data. Developed with an emphasis on performance and stability, MySQL is a system

for applications requiring structured data organization and integrity. The project's architecture is based on a cross-platform running on .Net Core, which will enable access to the application on both mobile and desktop using ReactJS, HTML, and CSS. The business logic will access the data through RESTful APIs provided by .NET Core. OAuth and JWT will be used for user login and authorization, ensuring the application's security. All these components will be hosted on the Azure cloud service, enabling the application to run and scale online.



2. Requirements

2.1. Functional Requirements

2.1.1. User Registration and Login System

- A system that allows users to register and log in to the application.
- Secure storage of user information.
- A user interface suitable for children's ages.

2.1.2. Dyslexia Diagnosis Tests Module

- Interactive tests and assessments to determine users' dyslexia status.
- Record test results and provide feedback to parents/users.

2.1.3. Educational Games Module

- A variety of educational games that address challenges specific to dyslexia.
- Each game has goals to improve children's reading and writing skills.
- We are monitoring children's progress through games and recording this progress.

2.1.4. Parent/User Monitoring and Reporting

- Parents can monitor the child's activities and progress within the application.
- We are providing periodic reports and recommendations to parents.

2.1.5. User-Friendly Interface

- An intuitive and visually appealing user interface that children can easily use.
- Easy navigation and straightforward instructions within the app.

2.1.6. Data Security and Privacy

- Secure storage and processing of user data.
- Clearly state privacy policies and protect users' data.

2.1.7. In-App Help and Support

- Help sections that guide users on how to use the app.
- Availability of technical support and feedback mechanisms.

2.2. Non-Functional Requirements

2.2.1. Performance

- Fast loading of the app and low latency.
- Performance optimized for multi-user support.
- Scalability and resource management are provided by Azure infrastructure.

2.2.2. Security

- Encryption of user data and secure data transfer.
- Effective use of Azure security features (e.g., firewalls, authentication mechanisms).
- Privacy policies and compliance are designed specifically for children.

2.2.3. Availability

- It is an easy-to-understand and intuitive user interface.
- The design is suitable for children's age and skill levels.
- Multi-platform support (e.g., iOS, Android, web).

2.2.4. Reliability

- High availability and reduced system interruptions.
- Managing data backup and disaster recovery plans via Azure.
- Automatic updates and regular maintenance.

2.2.5. Scalability

- It automatically increases resources as users increase.
- We are leveraging Azure's scaling capabilities.
- Flexible management of data storage and processing capacities.

2.2.6. Compatibility

- Compliance with local and international laws regarding protecting children's data.
- Compliance with educational standards and best practices for dyslexia.

2.2.7. Sustainability

- Use of Azure's environmentally friendly features for energy-efficient operations.
- Long-term sustainable development plans.

2.3. Constraints and Assumptions

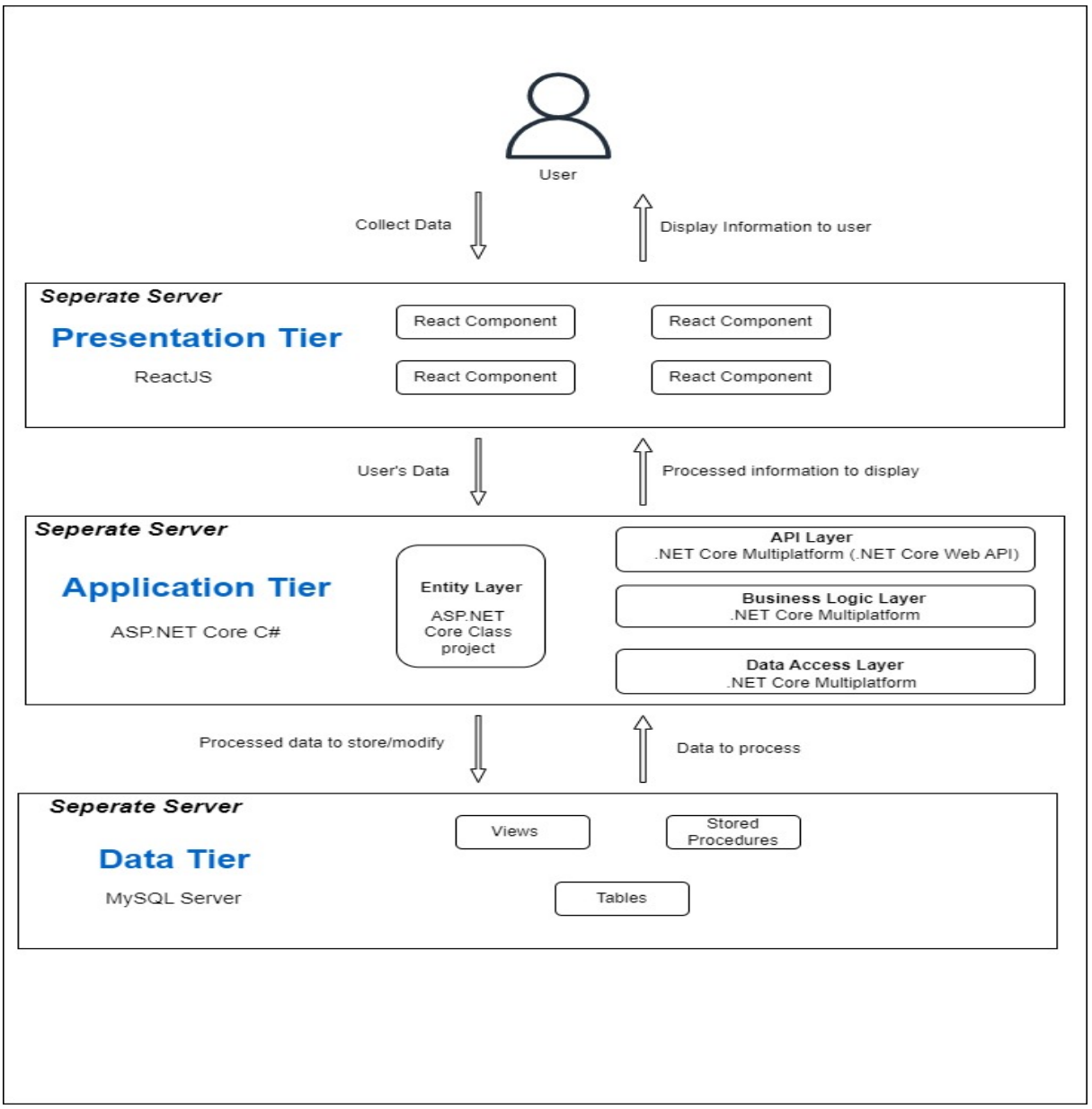
The system will be optimized for desktop and mobile devices. Performance will decrease due to internet connection requirements and low internet speeds. There will be compliance with legal regulations regarding children's data privacy and security. There will be compliance with regulations regarding education and health.

- The system assumes a reliable internet connection.
- It operates within the constraints of web browser capabilities.

3. Architecture

3.1. A High-Level Overview of the Software Architecture

Consists of three tiers: client, server, and database. The arch project is architecture-based on a cross-platform application running on .NET Core and has a user interface developed using ReactJS, HTML, and CSS. This application will store critical data using the MySQL database, and the business logic will access this data through RESTful APIs provided by .NET Core. OAuth and JWT will be used for user login and authorization, ensuring the security of the SECU application. These components will be hosted on the Azure cloud service, enabling the application to run and scale online.

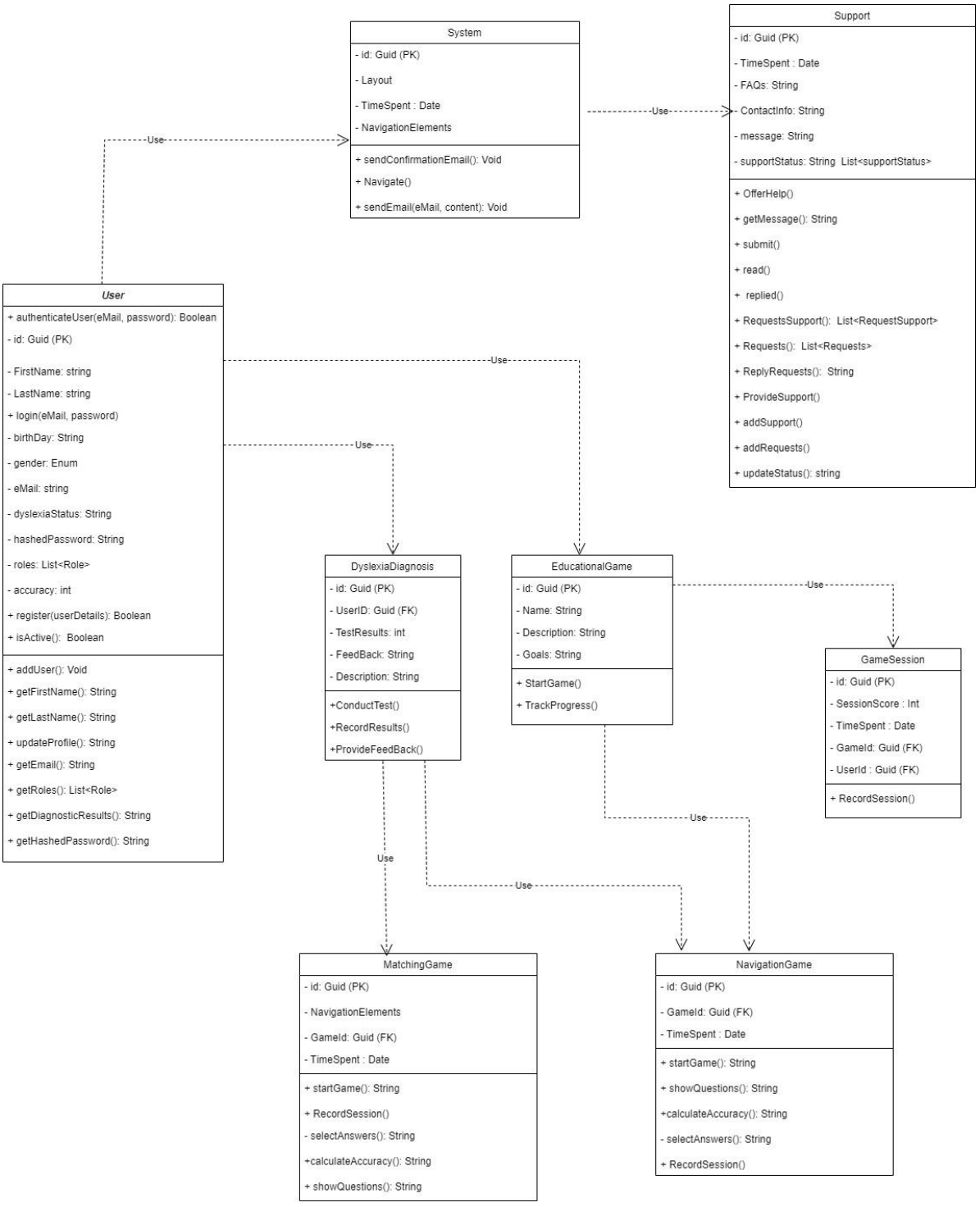


3.2. Used Technologies

- Back-End Programming: .NET Core for application server, MySQL for Database.
- Front-End Programming: ReactJS, HTML, and CSS.

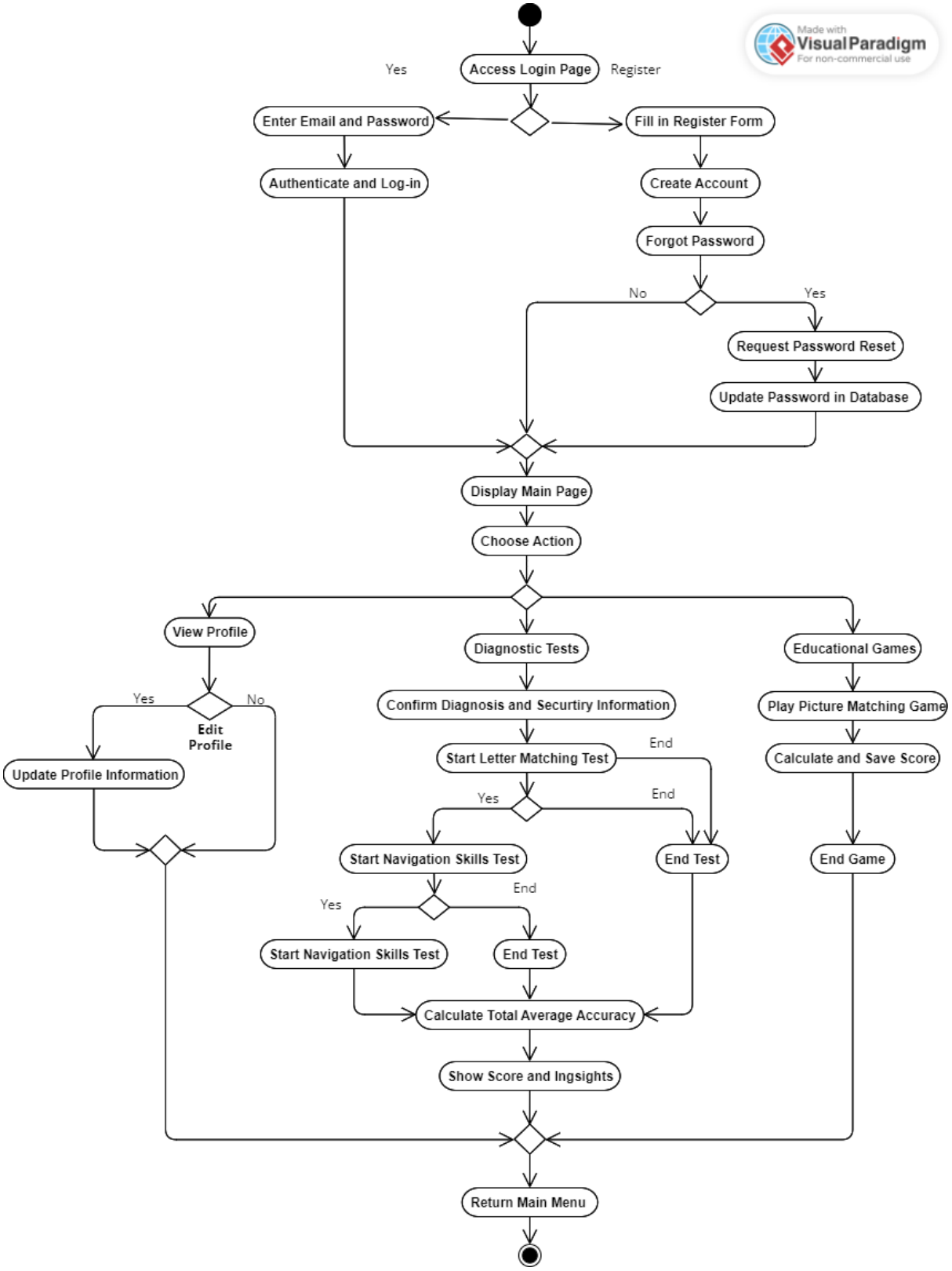
4. Diagrams or Sketches of the Architecture

4.1. Class Diagram

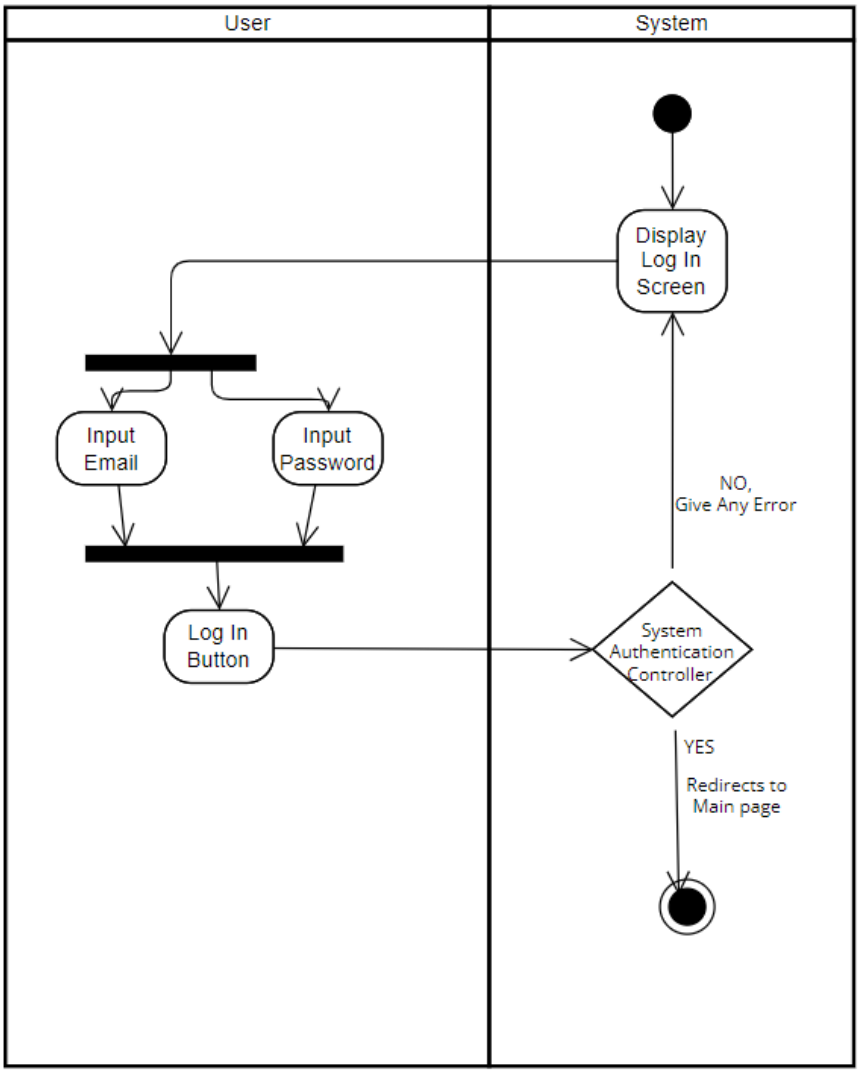


4.2. Activity Diagram

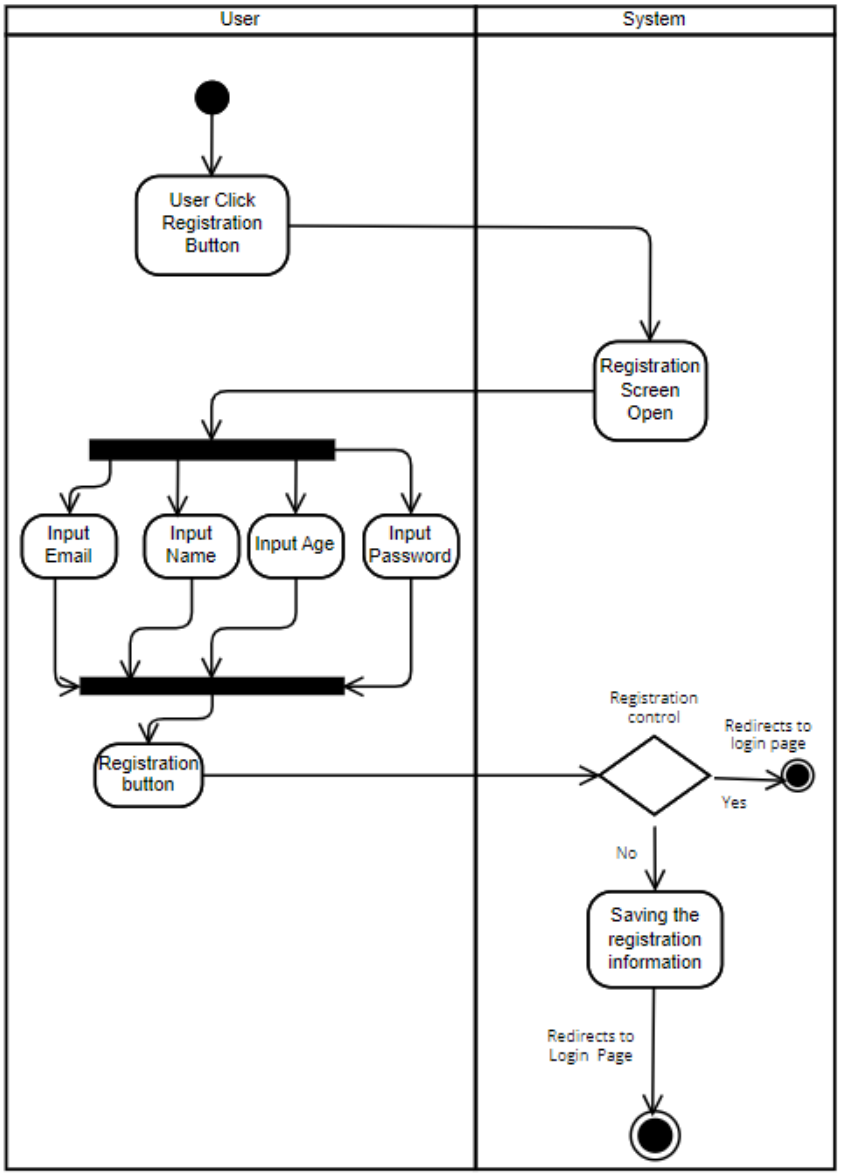
4.2.1. System Activity Diagram



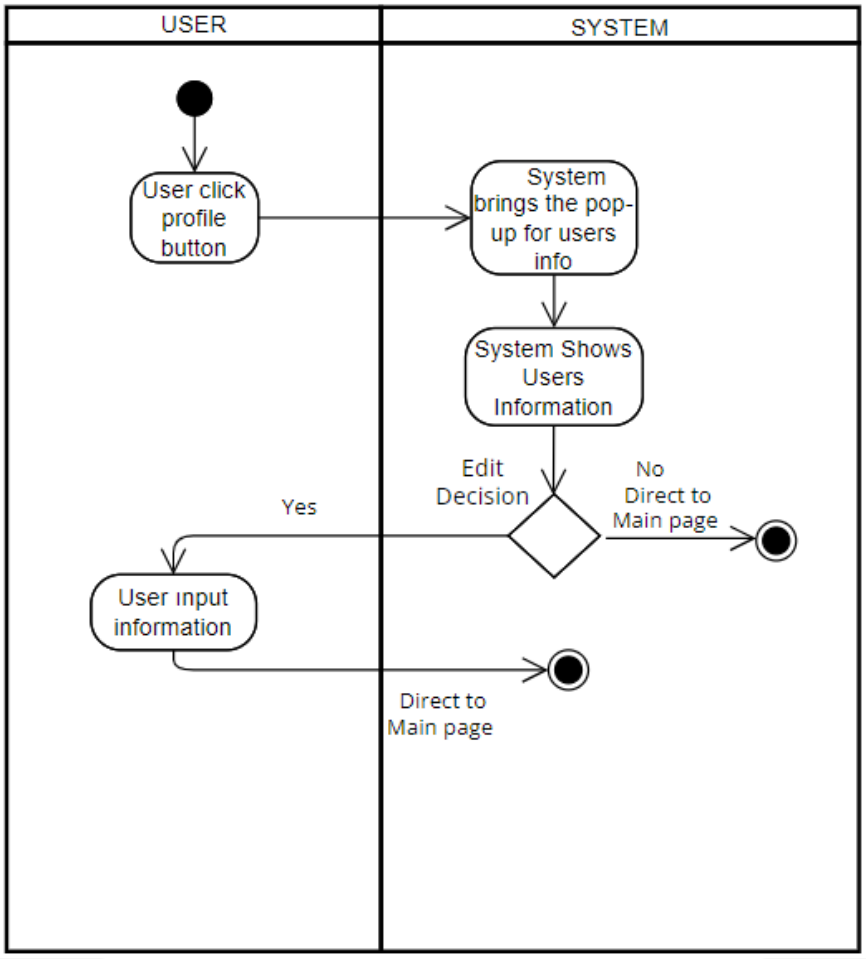
4.2.2. Login Activity Diagram



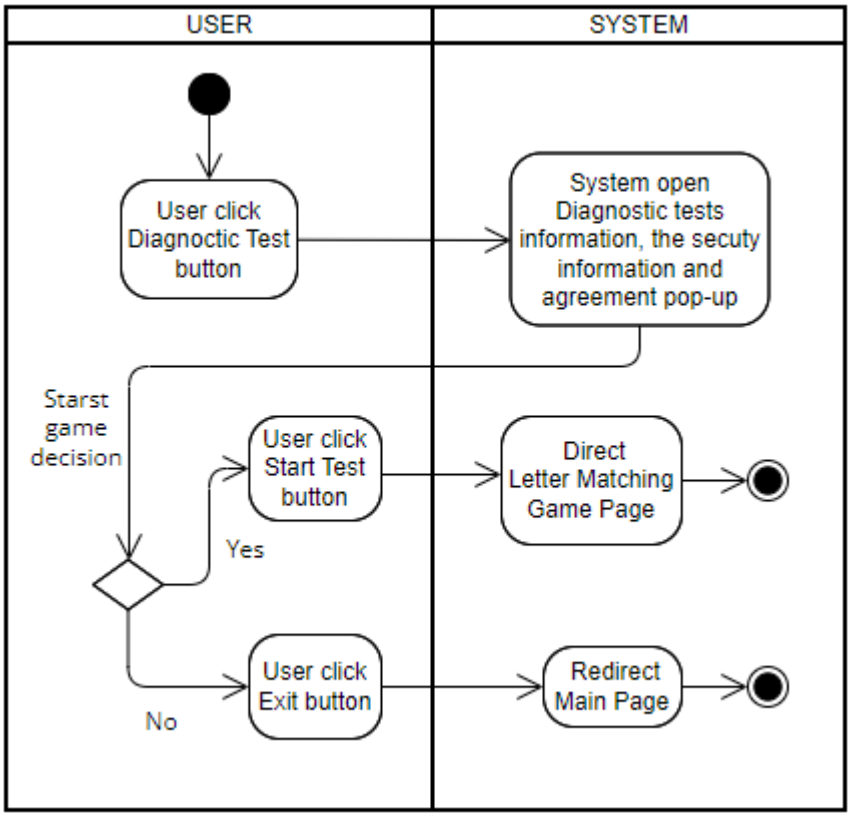
4.2.3. Register Activity Diagram



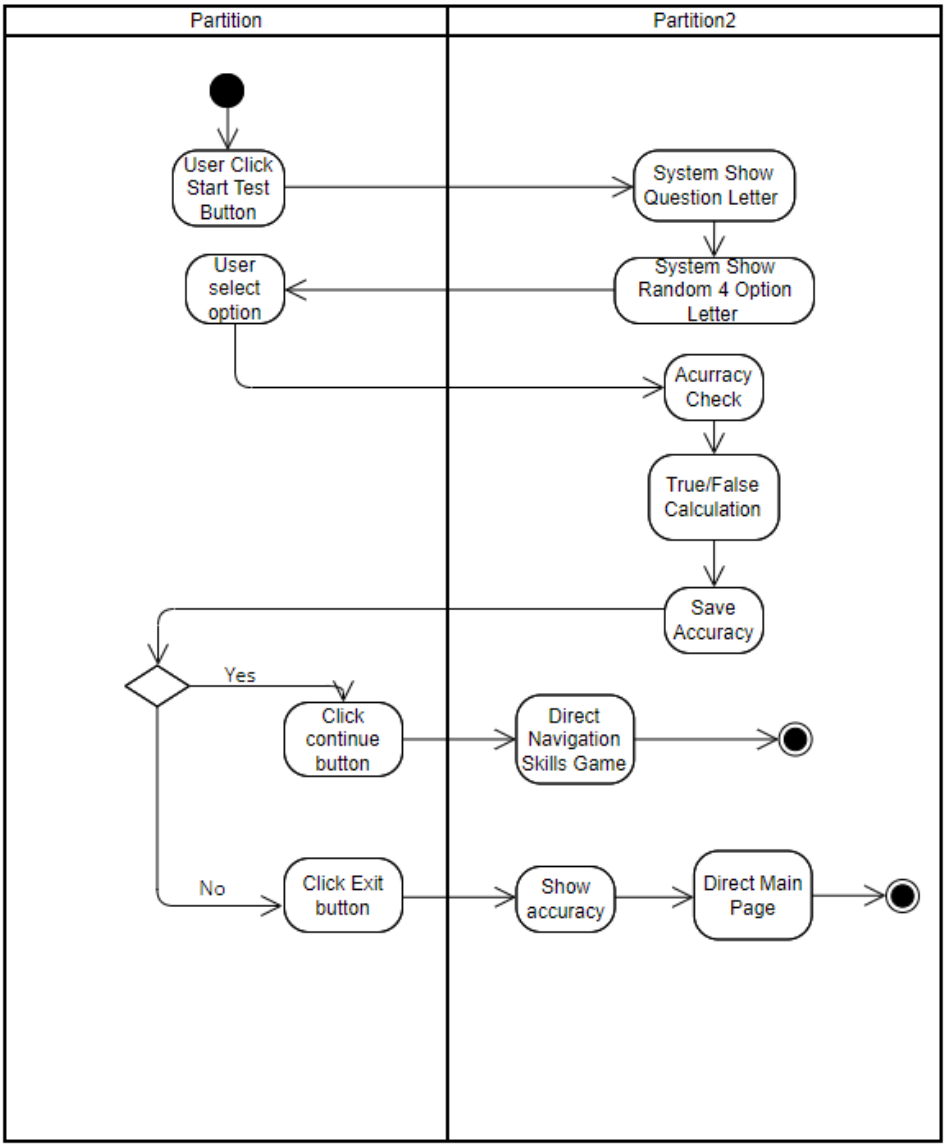
4.2.4. Profile Activity Diagram



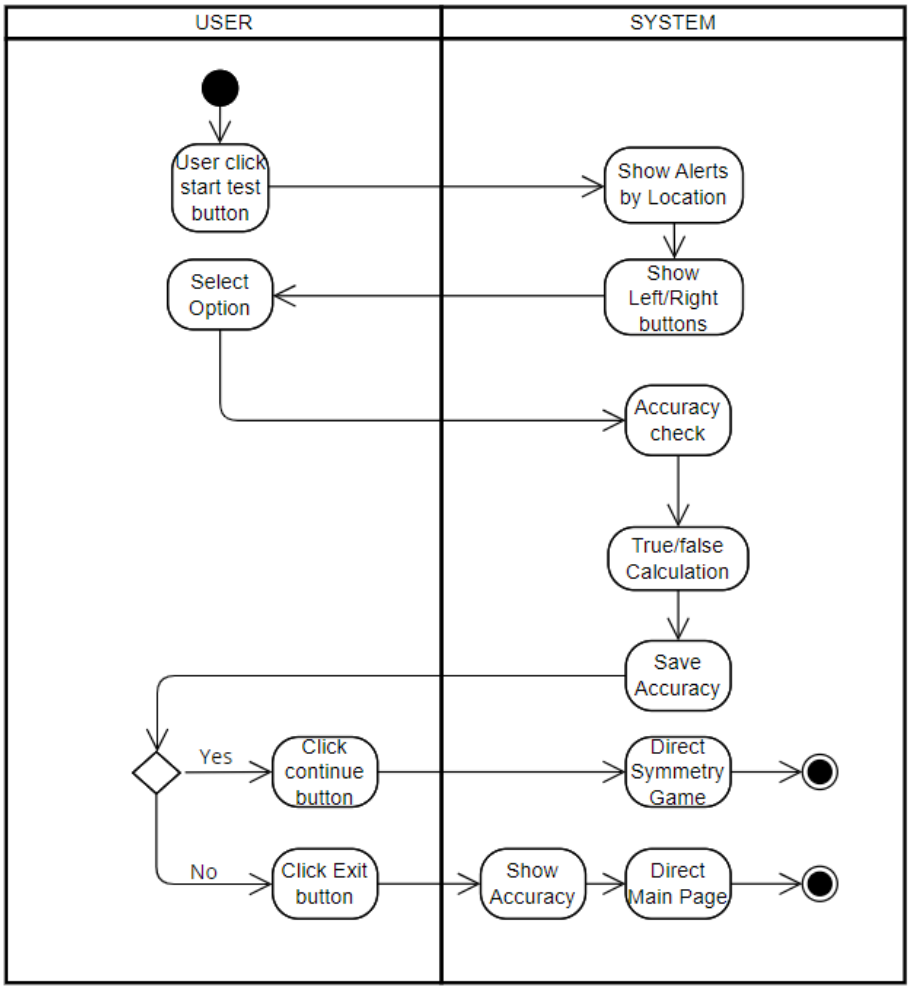
4.2.5. Diagnostic Tests Information Activity Diagram



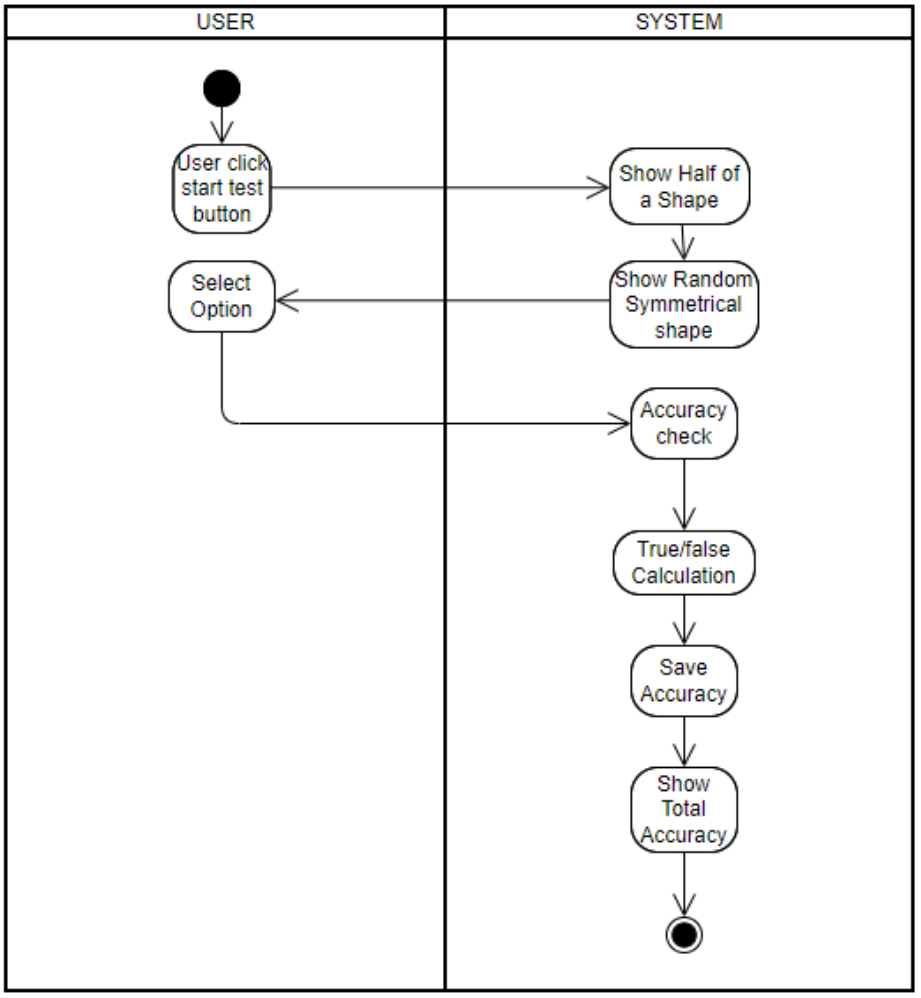
4.2.6. Letter Matching Test Activity Diagram



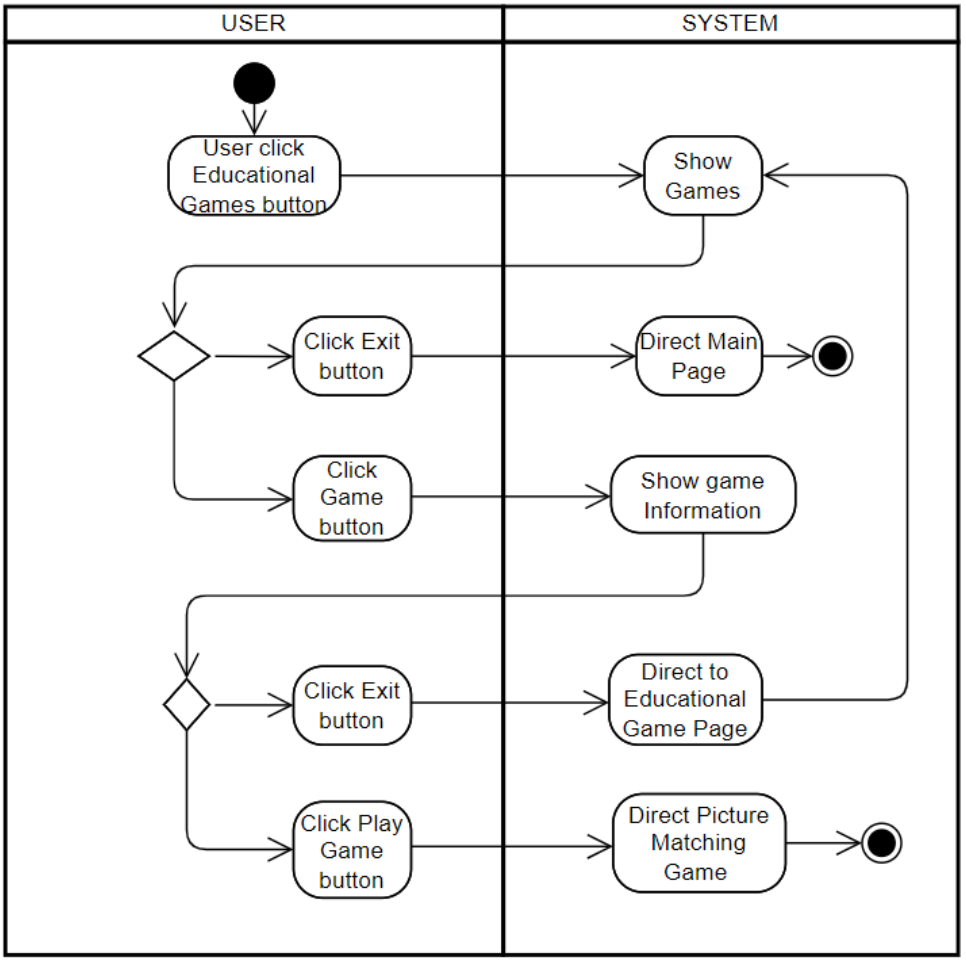
4.2.7. Navigation Skill Test Activity Diagram



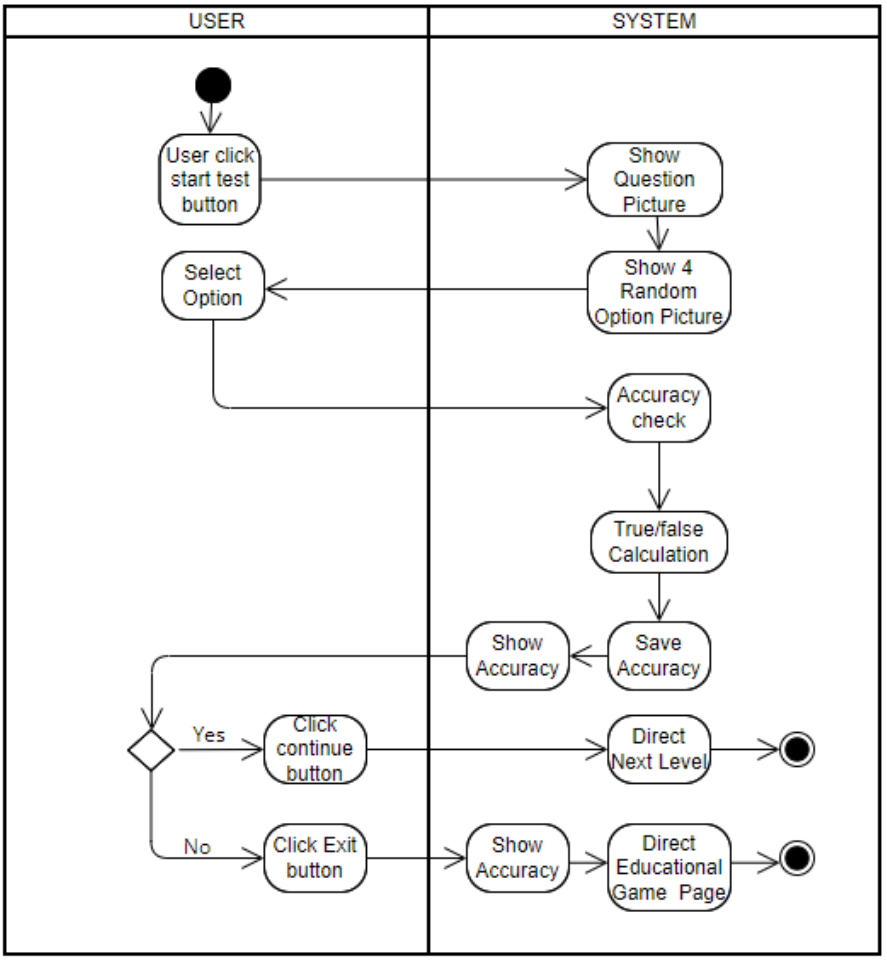
4.2.8. Symmetry Test Activity Diagram



4.2.9. Educational Game Activity Diagram

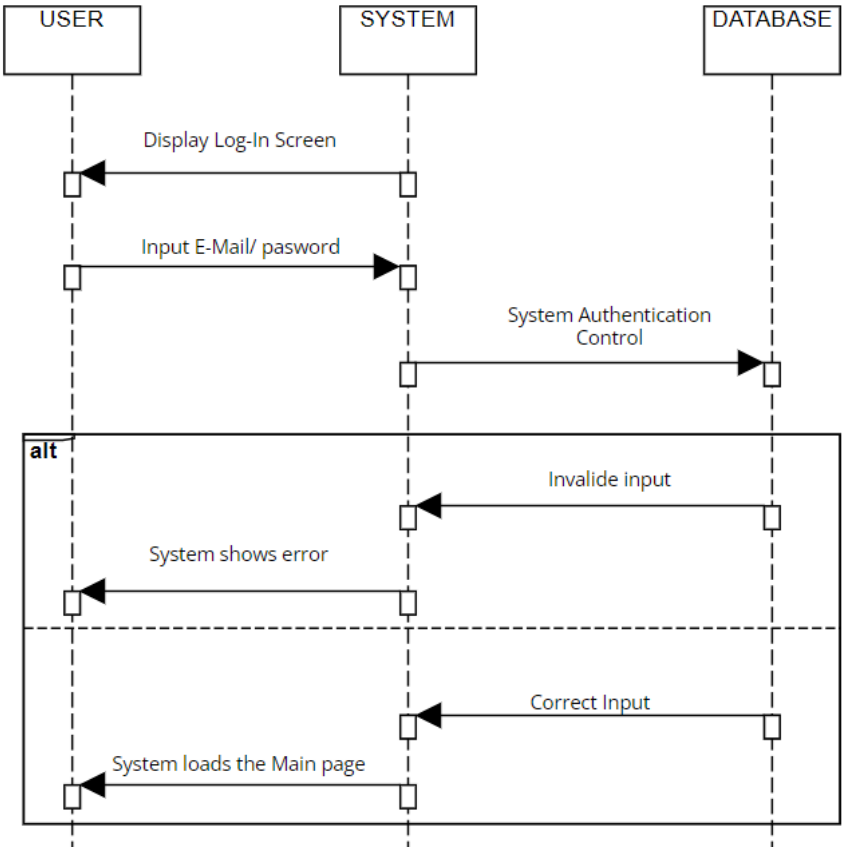


4.2.10. Picture Matching Game Activity Diagram

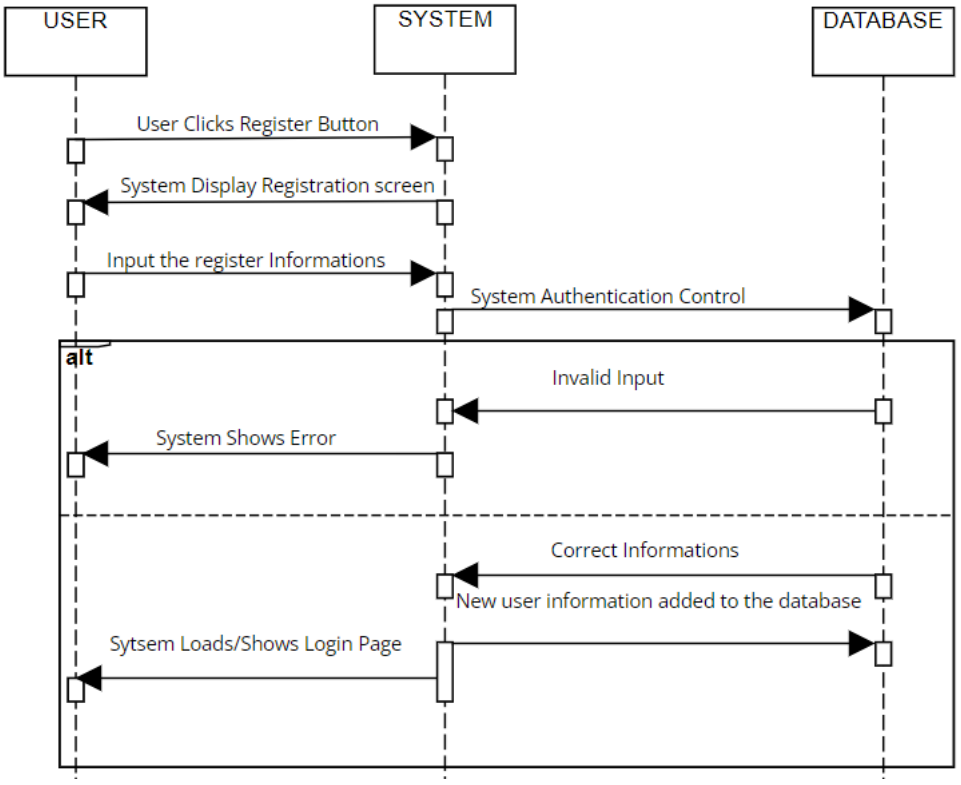


4.3. Sequence Diagram

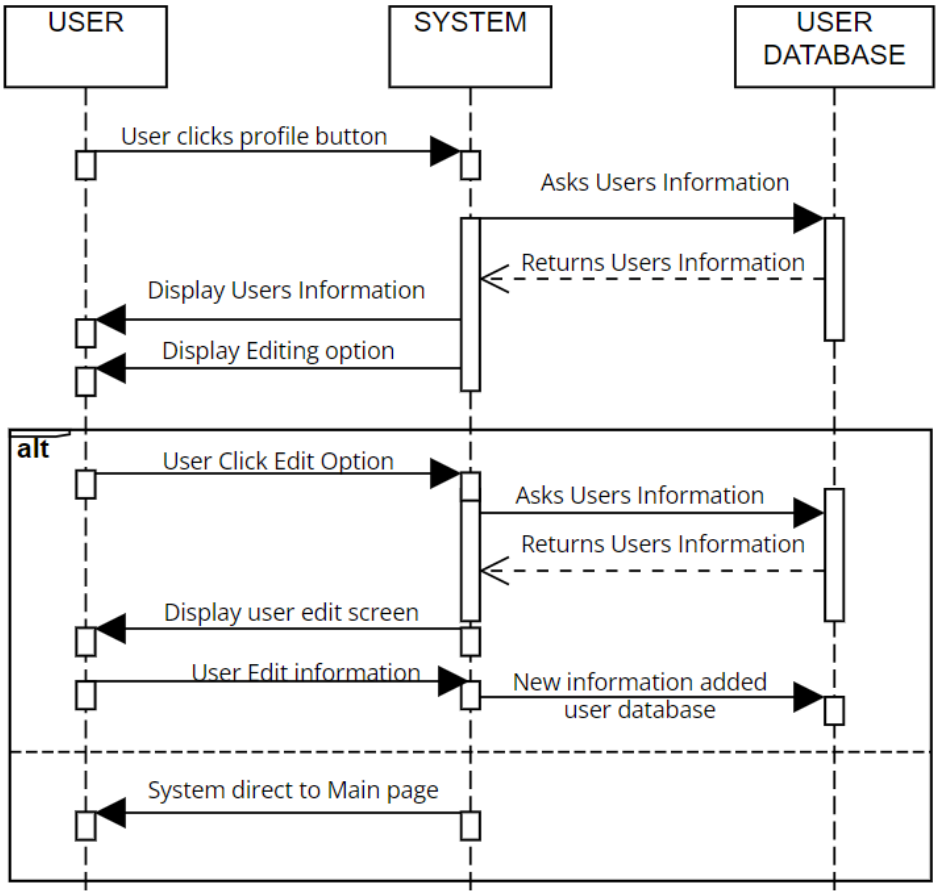
4.3.1. Login Sequence Diagram



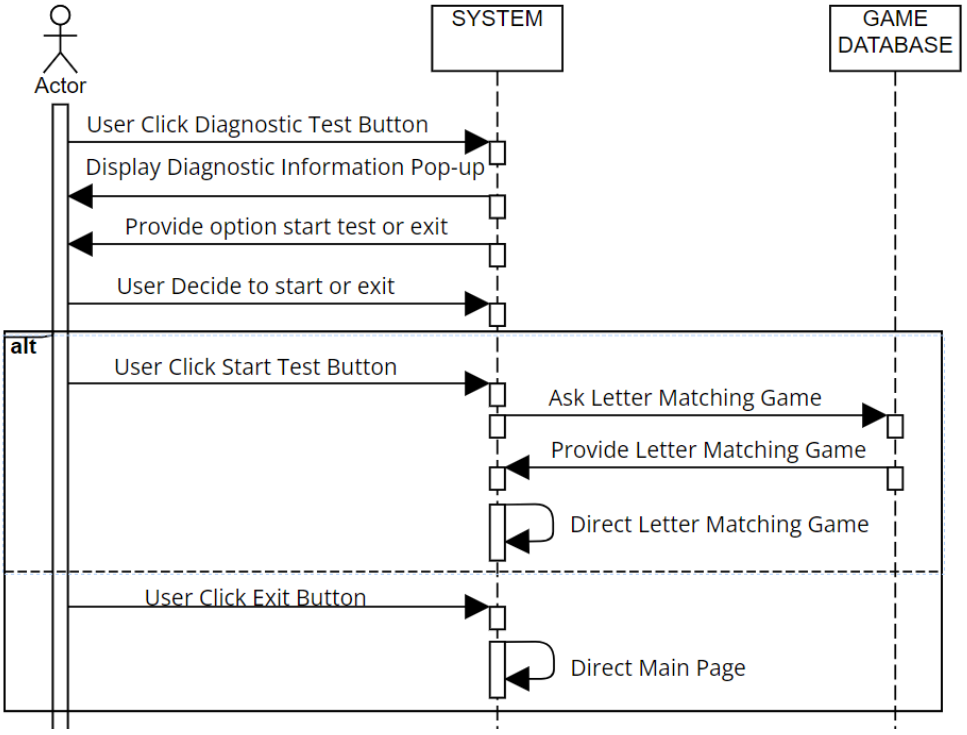
4.3.2. Register Sequence Diagram



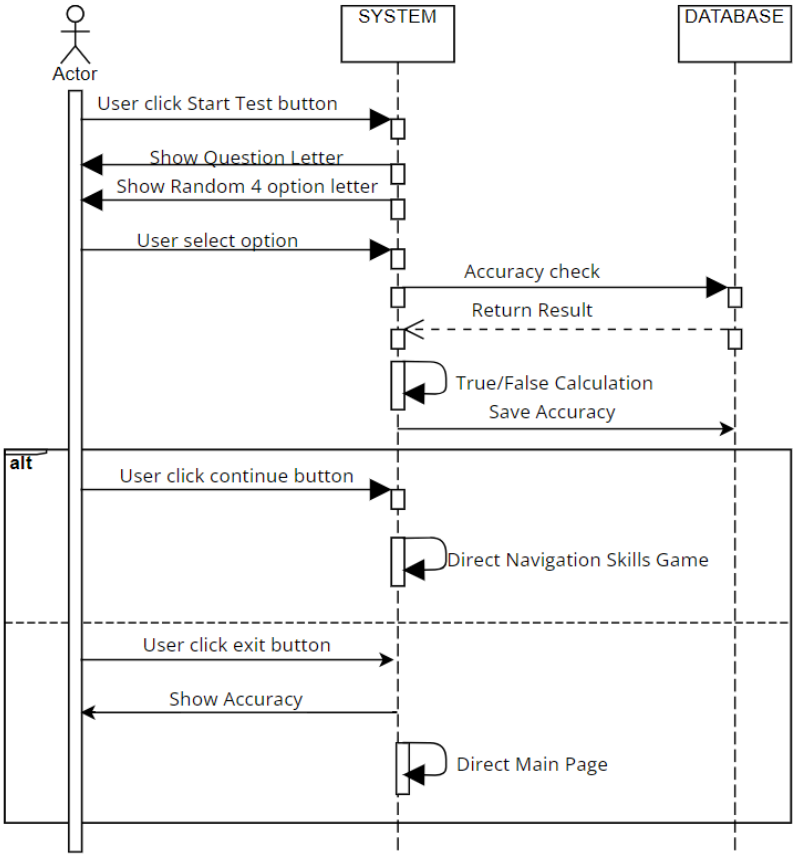
4.3.3. Profile Sequence Diagram



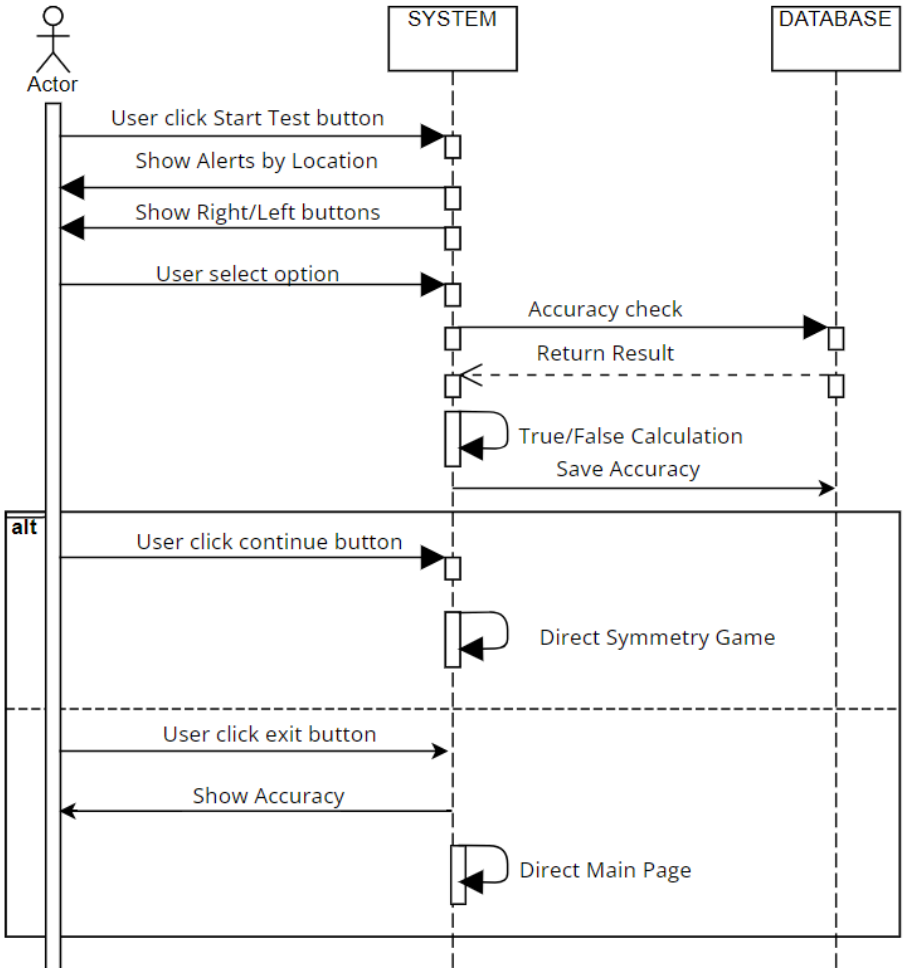
4.3.4. Diagnostic Tests Information Sequence Diagram



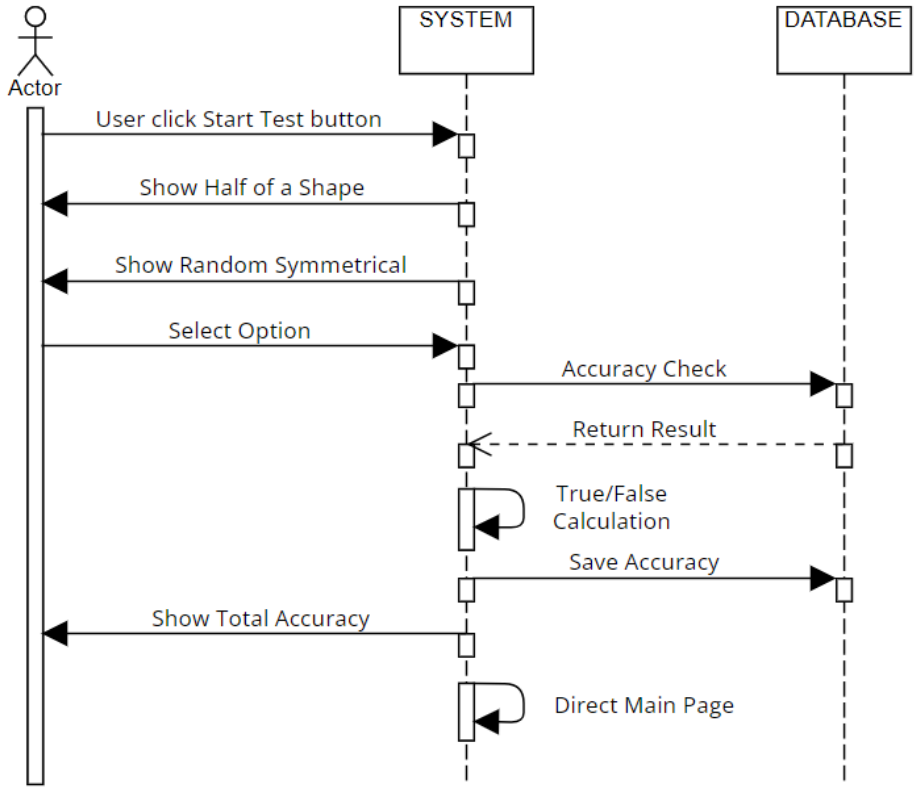
4.3.5. Letter Matching Test Sequence Diagram



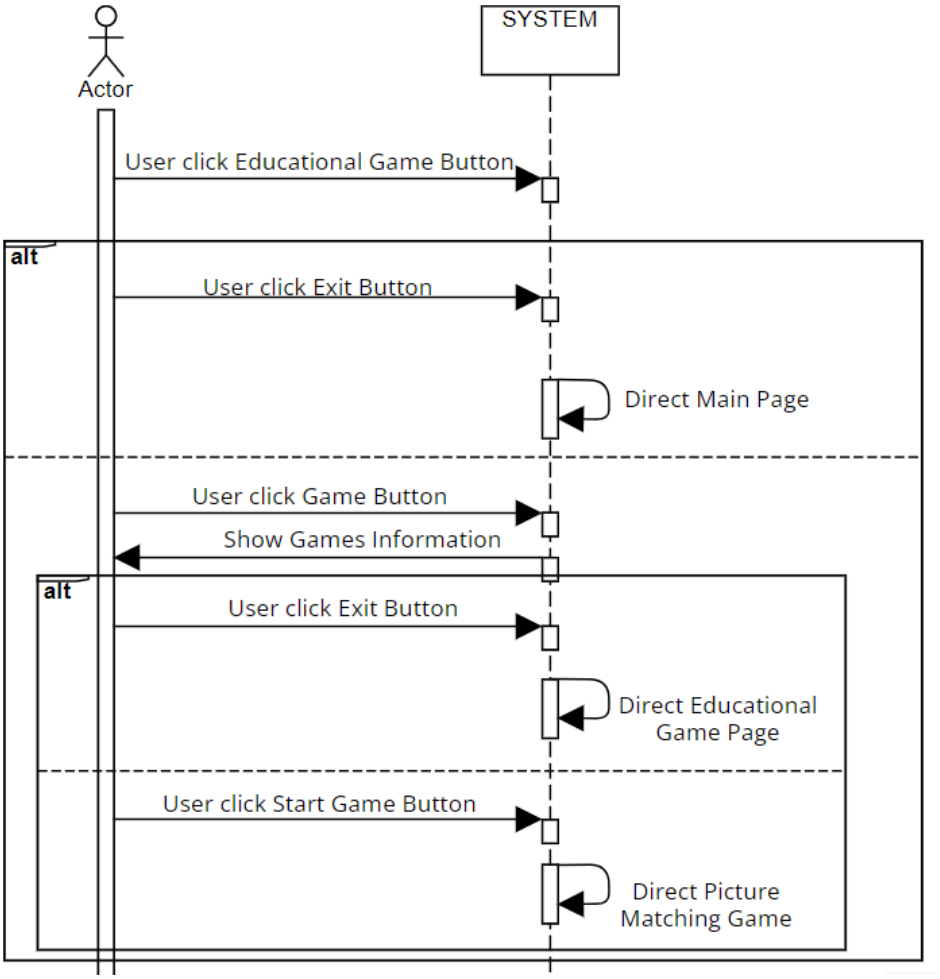
4.3.6. Navigation Skill Test Sequence Diagram



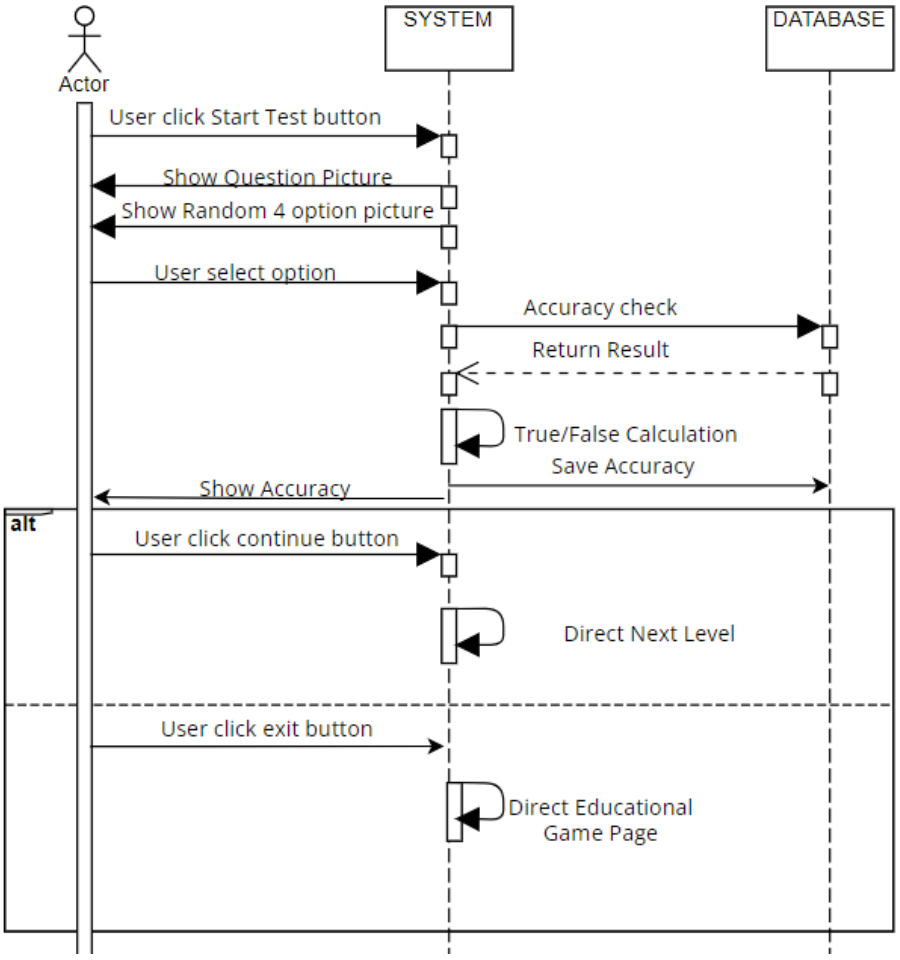
4.3.7. Symmetry Test Sequence Diagram



4.3.8. Educational Game Sequence Diagram



4.3.9. Picture Matching Game Sequence Diagram



5. User Interface Detailed Design

5.1. Detailed Design of Each Component

5.1.1. Login Page

5.1.2. Registration Page

5.1.3. Privacy Agreement for Registration

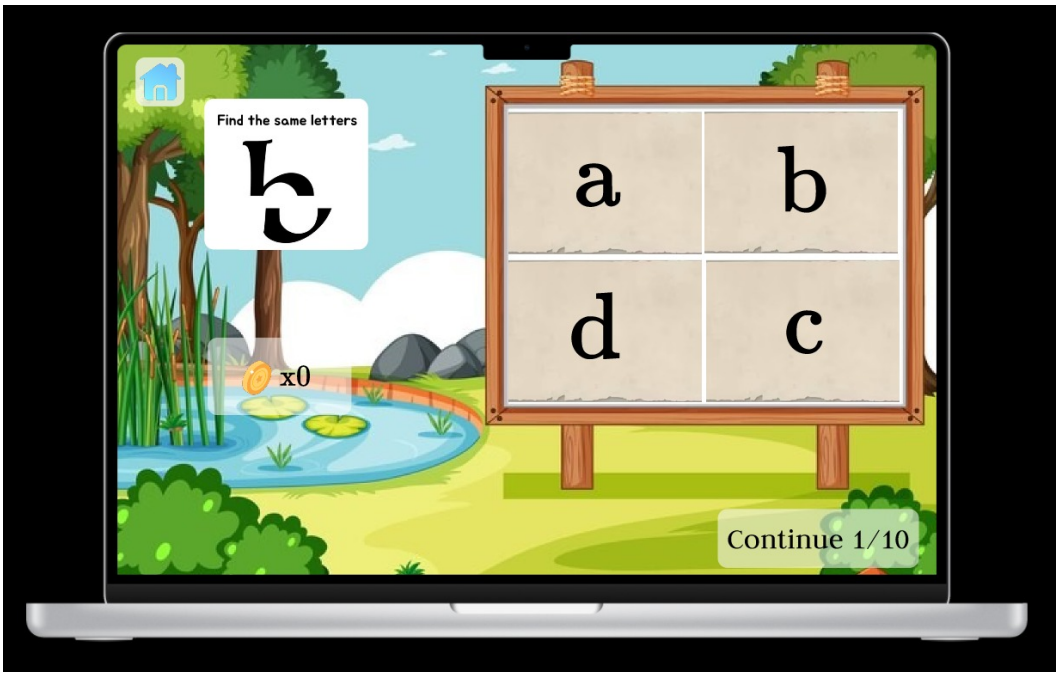
5.1.4. Forgot Password Page

5.1.5. Main Page

5.1.6. Privacy Agreement for Diagnostic Tests Page

5.1.7. Letter Matching Test Information Page

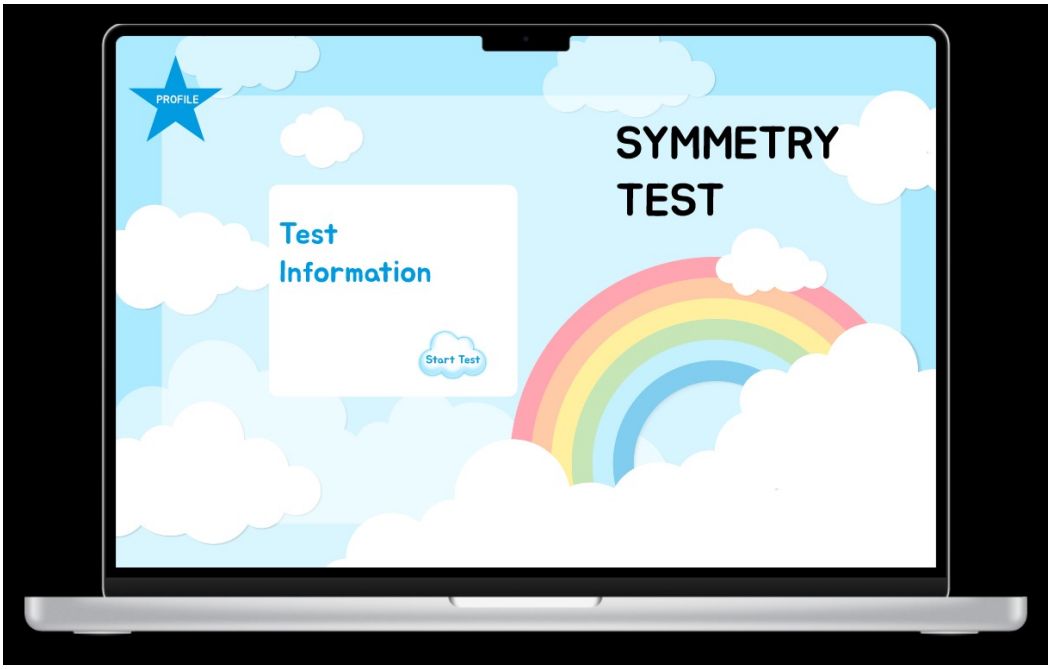
5.1.8. Letter Matching Test Page



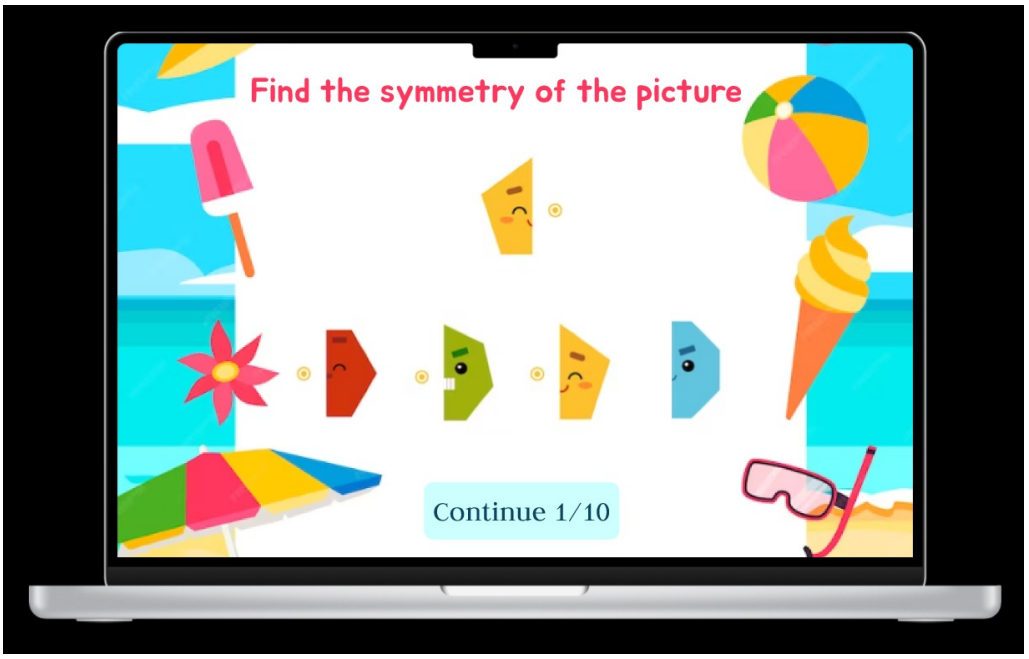
5.1.9. Navigation Skills Information Test Page

5.1.10. Navigation Skills Test Page

5.1.11. Symmetry Test Information Page



5.1.12. Symmetry Test Page



5.1.13. Educational Game Page

5.1.14. Picture Matching Game Information Page

5.1.15. Picture Matching Game Page

6. Implementation

6.1. Technologies Used

- Frontend: Angular, HTML5, CSS3, JavaScript
- Backend: ASP.NET Core, Node.js
- Database: MySQL

7. Testing

7.1. Testing Strategies

- Unit testing for individual components.
- Integration testing for end-to-end system functionality.
- User acceptance tests.

8. Conclusion

The Software Design Description (SDD) document is for the “Dyslexia Diagnostic Tests and Educational Games” project for dyslexic children aged four years and above. It outlines a comprehensive software development plan focused on early detection and support for children with dyslexia. The software has a user-friendly interface designed for children and includes diagnostic tests and skill-building activities. .NET Core uses a robust architecture that combines ReactJS, HTML, CSS, and MySQL with security and privacy considerations. Hosted in Azure, it provides scalability and performance. The document covers functional and non-functional requirements, user interface design, and implementation details, emphasizing accessibility, ease of use, and compliance with education and healthcare standards.

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